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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 210.
B. T. GALLOWAY, *Chief of Bureau.*

HINDI COTTON IN EGYPT.

BY

O. F. COOK,
Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.

ISSUED MAY 11, 1911.

WASHINGTON:
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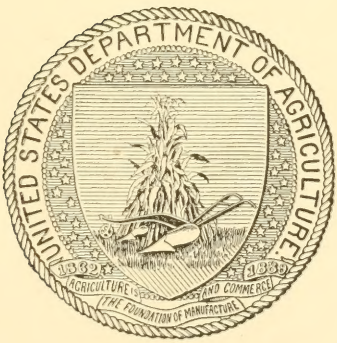

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 13, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Hindi Cotton in Egypt," by Mr. O. F. Cook, of this Bureau, and to recommend its publication as Bulletin No. 210 of the Bureau series.

This paper reports the results of a visit to the cotton-growing districts of Egypt in June and July, 1910. It shows that the admixture of inferior Hindi cotton is a serious burden upon the Egyptian industry and that our more intelligent farmers can secure an important advantage through the improved system of selection that has been developed by experiments in Arizona. A careful comparison of the results of the Arizona experiments with the conditions actually existing in Egypt became necessary in order to determine whether a satisfactory degree of uniformity has been attained in our acclimatized strains of Egyptian cotton. A previous study of the problem of diversity of the Egyptian cotton had been made in Arizona, as reported in Bulletins Nos. 147 and 156 of this series.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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HINDI COTTON IN EGYPT.

INTRODUCTION.

Inspection of many cotton fields in different parts of Egypt shows that the so-called Hindi cotton is a general contamination of the Egyptian stock, responsible for a large amount of diversity and degeneration. Expression of inferior Hindi characters renders many of the plants not only worthless from the standpoint of production, but dangerous to future crops. The establishment of a profitable culture of Egyptian cotton in Arizona and southern California depends largely on the exclusion of the Hindi contamination.[a]

The Hindi cotton complicates the problem of acclimatizing and adapting the Egyptian cotton to the cultural conditions found in the United States. In this case a problem of heredity had to be studied. Instead of the physical factors alone, it has been necessary to analyze the characters of the plants in order to determine the causes of impurity and find means of elimination.

[a] "Hindi is the name applied in Egypt to an undesirable type of cotton with a short, weak fiber, that injures the high-grade Egyptian varieties by infesting them with hybrids. The skill and cheapness of the native Egyptian labor enable the exporters to have the cotton sorted by hand in their baling establishments, so that a high reputation for uniformity has been secured in spite of the Hindi admixture.

"The introduction of the Egyptian cotton into the United States brings also the problem of the Hindi cotton, but without the resource of cheap labor which enables the difficulty to be surmounted in Egypt. The practicability of establishing a commercial culture of the Egyptian cotton in the United States depends largely upon the elimination of the Hindi contamination and other forms of diversity, so that the fiber may be produced in a satisfactory condition of uniformity. The Hindi cotton problem might be compared to that of the red rice that mixes with the white and depreciates the value of the crop. In the case of the cotton, there is a better prospect that adequate knowledge of the vegetative characters may enable the undesirable plants to be removed from the fields without too seriously increasing the cost of production." (See Circular 42, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "Origin of the Hindi Cotton," 1909, p. 3. This circular contains the results of a previous study of the Hindi cotton made in connection with experiments in Arizona. It will be sent free on application to the Secretary of Agriculture.)

During the first years of its cultivation in Arizona the Egyptian cotton produced only small yields and rather inferior fiber. After the yield and quality began to improve, an undesirable amount of diversity appeared. A study of this diversity showed that it was due in part to hybridization with the common American Upland cotton, and that this danger was unusually serious in Arizona when the two kinds of cotton are grown in the same locality, owing to an unusual abundance of wild bees. The Hindi cotton is an additional factor of diversity inherent in the imported Egyptian stock, more difficult to understand because not previously known in the United States.

Experiments show that both of these sources of diversity can be eliminated by a more careful system of field selection, applied early in the season before the inferior plants have begun to flower, and hence before they have cross-fertilized the neighboring plants. The value of the Arizona Egyptian cotton and the prospects of cultivating this crop on a commercial scale in the United States depend largely on the degree of uniformity that can be attained in the fiber, in comparison with that of the Egyptian product. Hence, the necessity for an inspection of the cotton fields of Egypt in order to determine the extent of diversity in the crop as raised in that country.

The high cost of labor in the Southwestern States forbids any direct imitation of Egyptian methods, either in raising the crop or in preparing it for market. Other solutions of the problems of production have to be sought. The requirement of uniformity has been met in Egypt by a system of careful grading of the cotton after picking that would be very difficult to establish in the United States, and too expensive to leave any assurance of profit for the farmer even if it were established.

The Egyptian cotton trade is organized on an entirely different basis from the American. Instead of merely ginning and baling the farmer's cotton as he brings it from the fields, it is the regular practice of the Egyptian ginning establishments to buy the seed cotton from the farmer and prepare it for the market by sorting, grading, and blending. Instead of depending entirely on samples, as with American cotton, Egyptian cotton is sold largely by the marks or brands that are placed on the bales by the ginning establishments. Cotton of the same mark is supposed to represent a definite uniform quality. This is much more practicable in Egypt than it would be in most parts of the United States because of the much greater uniformity of climate and soil in Egypt.

In comparison with the wide range of soils, climates, and seasonal vicissitudes in the cotton-producing districts of the United States, the Egyptian cotton industry gives at first an impression of complete uniformity. Although people in Egypt supposed that cotton would be more advanced in Upper Egypt than about Cairo, this did

not prove to be the case. It is quite possible that the crop of Upper Egypt comes to maturity earlier in the fall, owing to hotter weather in the summer, but there was very little difference at the middle of June. The effect that would naturally be expected from higher day temperatures in Upper Egypt may be neutralized in the early part of the season by cooler nights, due to the greater radiation allowed by the drier air. In any event the cotton was found at nearly the same stage of development about Beni-Suef as about Cairo and Tanta. (See Pl. I, fig. 1.) Even at the middle of July much of the cotton in Upper Egypt, between Beni-Suef and Minieh, was still quite small, having scarcely reached the flowering stage. In some fields the plants were only 6 or 8 inches high. The same was true of many fields in Lower Egypt in the region of Mansurah. (See Pl. II, figs. 1 and 2.) To what extent the later planting was responsible for the more backward state of the cotton in these districts was not learned, nor the reasons that may exist for later planting.

The most important local differences perceptible in Egypt were not those of the external conditions or of the methods of cultivation. The superiority of the cotton raised in the Delta region may be due in part to superior conditions, as generally assumed, but better knowledge of the Hindi cotton among the native cultivators is another factor of great importance, since it determines whether the inferior Hindi cotton shall be rogued out or left to mature in the fields. Many native cultivators at Beni-Suef pay no attention to the Hindi cotton, while about Mansurah it seems to be known to everybody. But even about Mansurah the human factor is by no means uniform, as shown by widely varying proportions of Hindi cotton in the different fields.

IMPORTANCE OF UNIFORMITY IN EGYPTIAN COTTON.

The requirement of uniformity increases with the presence of other good qualities of cotton. A long, strong cotton commands higher prices, because it can be spun into stronger or finer thread and used to make stronger or finer fabrics. An admixture of short, weak fibers not only reduces the strength of the threads and impairs the quality or durability of the fabric; it interferes also with the work of the spinning and weaving machinery by the more frequent breaking of the threads.

The superiority of the Sea Island cotton does not consist alone in its length and strength, but in its extreme uniformity. This is maintained by a highly developed system of selection, well recognized among the Sea Island planters but not yet applied to any other commercial type of cotton. The seed for each season's crop is raised by itself, apart from the general planting, and traces its ancestry

back to a single superior individual of two or three generations before.[a]

In the Egyptian system of cotton culture no attempt seems to be made to imitate the methods of the Sea Island planters. Even less consideration is given to selection than in the Upland-cotton industry of the United States. While very few planters of Upland cotton have been accustomed to select their own seed, it has at least been possible for them to buy seed of selected stocks of many of the Upland varieties, whereas planters in Egypt do not appear to have any recognized source of supply from which to secure uniform stocks of seed of the Egyptian varieties free from the Hindi contamination. Differences between the seeds of the Hindi and the Egyptian cotton enable a selection to be made, even after ginning, but it seems evident from the condition of the fields in Egypt that a considerable quantity of Hindi seed must be planted and that many Hindi plants are allowed to grow to maturity and so to maintain the contamination.[b]

The advantage that the individual planter might gain by a careful and persistent selection of his own seed is difficult to realize under the Egyptian system of selling the seed cotton to the ginner. There is also a custom of exchanging seed between different villages on the theory that better yields can be obtained in this way. Thus growers of Mit Afifi cotton near Mansurah obtain their seed from Kefir Zeyat, between Tanta and Alexandria, a place that is commonly supposed to produce seed of a superior quality. Such exchanges of seed are

[a] Webber, H. J. Improvement of Cotton by Seed Selection, Yearbook of the Department of Agriculture for 1902, p. 374.

[b] "The seed reserved for sowing is passed through special riddles, which remove small and dead seed; purity can not be obtained by this means, but merely a better looking sample; that is to say, as far as general appearance is concerned, the sample may be excellent, but closer examination reveals the presence of seed not true to variety. Small cultivators do not, as a rule, trouble even to secure the best seed which is procurable, but content themselves with the employment of that resulting from the ginning of common qualities of all pickings, regardless of origin and purity. Were this seed purchased at a low price it would provide no excuse for such a short-sighted policy, but even this is not the case, the price paid to the village merchant being, as a rule, considerably higher than that for which the better qualities could be obtained.

"In order to overcome this difficulty, the Khedivial Agricultural Society, in conjunction with the Agricultural Bank, distributes annually to small cultivators the best seed obtainable at cost price, the value of which is collected at the end of the following cotton season.

"It must be remarked, however, that the seed so distributed is merely the best that can be procured.

"That it is vastly superior to that which in the absence of such a system of distributing would be employed is without doubt. At the same time this system does nothing to actually improve the seed." (See Foaden, G. P., "The Selection of Seed Cotton," Yearbook of the Khedivial Agricultural Society, 1905, p. 122.)

well calculated to preserve and distribute the Hindi contamination. Even the introduction of new, carefully selected varieties could be expected to give only temporary improvement unless the whole system were changed. The process of deterioration would be resumed at once as a result of the crossing between adjacent fields of different varieties and the exchange of seed between different localities.

After selection is relaxed the rapidity of deterioration of a variety of cotton depends on two cooperating factors, variation and crossing. Both of these factors must vary in different places, for they are influenced by external conditions. When cotton is grown under new or unfavorable conditions, more numerous variations appear. Abundance of bees or other cross-fertilizing insects causes a more rapid spreading of variations through the stock. Relatively uniform conditions and apparent scarcity of insects may give longer life to varieties in Egypt than in the United States, but the general tendencies and results of deterioration seem to be quite the same.[a]

The history of cotton culture in Egypt shows that a succession of new varieties has replaced the old at intervals of a few decades. The modern Egyptian cotton industry began with the variety discovered and popularized by Jumel, a French engineer, about 1820. The Jumel cotton was replaced by the Ashmuni after 1860, the Ashmuni by the Mit Afifi about 1890, and more recent varieties, such as the Jannovitch and Nubari, are now replacing the Mit Afifi. Other varieties, such as the Bamieh, Gallini, Zafiri, Abbasi, Sultani, etc., have either failed to gain any general popularity or have aroused only temporary interest.

LINT AND SEED CHARACTERS OF HINDI COTTON.

The character that renders the Hindi cotton so unwelcome as an element of admixture in the Egyptian stock is the much shorter and coarser fiber. The Hindi fiber is also pure white in color, whereas in the more popular Egyptian varieties the lint is a somewhat creamy white, tinged with buff or brown. White-linted varieties of Egyptian cotton have been cultivated to a small extent, but have never become popular in Egypt.

The difference in the color of the lint is of much assistance in the work of sorting out the Hindi admixture after the fiber has been picked and brought to the ginning establishment. Any thorough separation of the inferior Hindi fiber from a white variety must be

[a] Though very few insects were noticed in the Egyptian fields in June and July, they may be more abundant later in the season. Balls reports between 5 and 10 per cent of crossing, and even 25 per cent in one of his experiments. (See Balls, W. L., "Cross-Fertilization in Cotton," Cairo Scientific Journal, vol. 2, 1908, p. 405.)

much more difficult, if not entirely impracticable. From this point of view it is easy to understand why the culture of Sea Island cotton or of the superior white varieties of Egyptian, such as Abbasi, has not become more extensive.

The superiority claimed for the lint of the white varieties, such as Abbasi, is in accordance with other indications of a general correlation between the color and the length of the lint. Study of the lint characters of many variations and hybrids seems to indicate a general tendency in brown fibers to be shorter and coarser than white fibers. Thus the Jannovitch variety has lint longer and whiter than the Mit Afifi, though still with a very slight tinge of brown. The Abbasi lint is still longer, but is pure white in color.[a]

If the need of sorting the fiber were removed by more effective methods of eliminating the Hindi variations, the way would be open to a larger use of white-linted varieties. Though brownish lint is preferred for a few purposes, the color seems to be valuable chiefly for the aid it gives in sorting out the inferior fiber that results from the Hindi contamination. If American growers are sufficiently careful to keep out the Hindi contamination, they may be able to grow white varieties that have longer and stronger fibers than the brown-linted varieties now popular in Egypt.

In addition to the long fibers that compose the lint, the seeds of typical Egyptian plants are always provided with short fibers, or "fuzz," that continue to adhere to the seed after the lint has been removed by ginning. The fuzz may be confined to small tufts at the ends of the seed or may extend down one side, or may be more widely spread over the surface. The seeds of the typical Hindi cotton, on the other hand, are entirely without fuzz. The black surface is left entirely naked after the lint has been removed. The absence of fuzz makes the small, sharp-pointed, black stalk or funiculus at the base of the seed much more conspicuous in the Hindi cotton, though it is present in other varieties.

The seeds of the Hindi cotton are more angular in shape than those of the Egyptian cotton. Though not adhering like the seeds of kidney cotton, they seem to be more closely crowded together in the boll than the seeds of the Egyptian cotton, and this mutual pressure tends

[a] The production of Abbasi cotton is said to be irregular because the price fluctuates with Sea Island cotton. When Sea Island cotton is cheap there is small demand for the Abbasi. Another variety that gave very promising results in an experiment in Arizona in 1909, the Nubari, is said to be not very highly appreciated in Egypt because of a tendency to produce small bolls. While many small-bolled plants were found in the Nubari field in Arizona, there was less diversity in this and other respects than in any other lot of plants grown from imported seed.

to make the Hindi seeds longer and more angular. Fully developed Egyptian seeds are usually plump, with all the sides distinctly convex and with a larger diameter than the Hindi seeds.

The smooth surface and narrower shape of Hindi seeds make it possible to separate most of them by sifting, as the Egyptian ginning establishments are said to do. Nevertheless, it is not to be expected that any complete elimination of the Hindi cotton can be accomplished in this way, for Hindi plants are occasionally found with fuzzy seeds much like the seeds of American Upland cotton. The seeds of Hindi hybrids are also somewhat fuzzy, often in the same way as the Egyptian seeds.

Hand selection of seed intended for planting is said to be done in Egypt, though it does not seem to be a regular practice. Experiments carried on by Mr. Argyle McLachlan in Arizona indicate that Hindi variations and other aberrant tendencies can usually be detected if the seeds are studied with sufficient care and discrimination.

The sorting out of the Hindi cotton is also assisted by the fact that the Hindi lint is very lightly attached, allowing the black surfaces of the seeds to be very readily seen. Even before the cotton is picked from the plants this difference is often very apparent.

In addition to being short and coarse, the fibers of the Hindi cotton are relatively straight and have very little tendency to cling together, like the longer and more abundant fibers of Egyptian and Upland varieties. After the Hindi bolls are open the seeds soon begin to separate and fall out, especially if they have a little assistance from wind or rain. In other words, the Hindi cotton is conspicuously lacking in storm-proof qualities.

The naked surfaces of the Hindi seeds may be responsible for the fact that young plants of the Hindi cotton often appear to make more rapid growth than adjacent Egyptian plants. Experiments have shown that the germination of fuzzy-seeded varieties may be seriously delayed in dry weather, while seeds without fuzz may germinate promptly in the same soil. Obviously, too, a Hindi seedling that had germinated promptly and had sent out roots to absorb water would retard the germination of other seeds in the same hill. The cotton is planted in Egypt in relatively dry soil, the young plants being easily destroyed by any excess of water. Under such conditions there is usually a very unequal development of the young plants. Two or three plants in each hill, or perhaps only a single one, may develop several leaves and attain a height of 8 or 10 inches, while the other seedlings of the same hill remain with only the cotyledons expanded.

DISTINCTIVE CHARACTERS OF HINDI PLANTS.

HABITS OF GROWTH OF HINDI COTTON.

If the Hindi cotton could be recognized only by the characters of the lint and seeds, it might be impossible to effect a complete elimination of the Hindi characters by selection. As long as Hindi plants are allowed to flower in the fields with the Egyptian plants and cross-fertilize them the undesirable Hindi characteristics may be expected to reappear. Even if no seeds of the Hindi form are planted, some of the apparently normal Egyptian seeds are likely to contain Hindi hybrid embryos, and these in turn can grow to maturity and produce pollen for continuing the Hindi infection to further generations. It is fortunate, therefore, that the Hindi cotton has several very definite differences in the vegetative parts, so that all Hindi plants can be recognized and rogued out of a field or a seed plat before the age of blooming and cross-fertilization is reached.

The general form or habit of growth of the Hindi plants is different from that of the Egyptian cotton, though this is not so apparent in the Egyptian fields, where the plants are crowded closely together, as in experimental plantings, where more space is allowed the individual plants. The tendency of the Hindi cotton is to produce a broader and more bushy plant, more like the Upland than the Egyptian cotton. (See Pl. I, fig. 2.)

There is a general impression that the Hindi cotton is larger and more luxuriant than the Egyptian, but this may relate to the Hindi hybrids rather than to the genuine Hindi individuals. The Hindi plants may appear larger early in the season, perhaps as a result of more prompt germination, but they are usually outgrown by the neighboring Egyptian plants by the time the fruiting stage is reached.

The Egyptian cotton, as well as the Hindi, shows different habits of growth under different conditions. In the cooler climate of Lower Egypt there is no such luxuriance of vegetative growth as in Arizona, but the branches are more spreading and the foliage more open. The habit of the Egyptian cotton in Egypt is more like that of Upland cotton in our Southern States. The similarity was especially strong in the Fayum Oasis, where some of the cotton is planted on rather poor land. It flowers and fruits when only 8 or 10 inches high, maturing small, bushy plants, like Upland cotton on poor soil in the South. Something of the exuberant tendency was shown in an experimental planting of Egyptian cotton at Siut (Assiut), in Upper Egypt.

The habits of branching of the Hindi cotton are also different from those of the Egyptian. The fertile branches are less definitely specialized than in the Egyptian cotton and have a stronger tendency

to grow in upright or oblique positions and to assume the functions of vegetative branches, the flower buds being often aborted.[a]

LEAF CHARACTERS OF HINDI COTTON.

The leaves of the Hindi cotton are characterized by thinner texture and lighter color, a fresh, bright green that forms quite a definite contrast with the duller grayish or bluish green of the Egyptian leaves. The surfaces of the leaves of the Egyptian cotton are somewhat duller and more hairy in Egypt than in Arizona, though not so grayish as when the Egyptian cotton is grown in the cool climate of the Pacific coast, near Los Angeles. The color is usually darker before the fruiting stage of the Egyptian cotton is reached, when the foliage usually takes on a lighter and more yellowish tone. The dark foliage of the vegetative phase may be retained under conditions of abnormal luxuriance, or the change to the yellower shade of green may occur prematurely if the plants are affected by some unfavorable condition, such as too much water or too little.

The veins of the leaves of the Hindi cotton are usually reddish, and the red color becomes very pronounced at the pulvinus or cushion-like thickening at the bases of the veins, where they pass into the petiole or stem of the leaf. The two large veins on each side of the midrib are particularly likely to be grown together at the base, giving the pulvinus of the Hindi cotton an oblong shape. The leaves of the Egyptian cotton do not have an enlarged pulvinus, the veins passing more directly into the petiole without becoming much swollen or united at the base. The surface of the pulvinus of the Hindi cotton is naked, or with only a few scattering hairs, while the corresponding part of the Egyptian cotton is usually quite hairy.

The lack of specialization of the bases of the veins in the Egyptian cotton seems to render the leaves less capable of movement. They do not appear to change their positions to face the sun in the morning and afternoon as much as the leaves of the Hindi cotton. The turning of the leaves to the sun renders the Hindi plants more conspicuous in the morning and afternoon than in the middle of the day, when the leaves have a horizontal position. Advantage was taken of this fact in making inspections of fields from moving trains, as will be explained later.

Even in the first leaves or cotyledons of the young seedlings the reddening of the veins and the basal spot enables the Hindi cotton to be recognized and separated from the Egyptian. The difference of coloration is not so obvious in the first few leaves that appear after the cotyledons, for even in the Egyptian cotton these are likely

[a] Dimorphic Branches in Tropical Crop Plants, Bulletin 198, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

to have a somewhat reddish spot at the base, especially if the conditions are not favorable for rapid growth. The differences become more obvious as the plants grow, until the flowering stage is reached, but they may lessen or disappear at maturity. In adult Egyptian plants the veins of the leaves often become reddish, while those of adult Hindi plants may become pale.[a]

After the color contrasts have disappeared, the recognition of the Hindi plants requires notice of other less obvious details of the leaves, flowers, and bolls. Thus the leaves of the Hindi cotton have the lobes broader, more abruptly narrowed toward the apex, and usually produced into longer terminal points. In Hindi hybrids there are often 5 to 7 lobes which are often somewhat folded or plicate, as in the Egyptian cotton, the true Hindi plants having the leaves nearly flat. The rounded basal lobes of the leaf are broader in the Hindi cotton, so that the leaf as a whole is more nearly square or oblong in shape. The corresponding margins of the Egyptian leaves are likely to converge or slope backward toward the stem.[b]

The sinus or notch at the base of the leaf, where the petiole is inserted, is usually much broader in the Hindi cotton, exposing the upper surface of the end of the petiole. In the Egyptian leaves the sinus is generally very narrow or completely closed by the contact or overlapping of the margins of the lobes. The wider separation of the lobes of the Hindi cotton may be considered as a consequence of the thickening of the veins and the enlargement of the end of the petiole

FLORAL CHARACTERS OF HINDI COTTON.

The involucre that incloses the bud of the cotton plant is composed of three bracts, small leaf-like organs, each margined with a fringe of narrow teeth. The bracts of the Hindi cotton are more broadly rounded at the base and have longer and more numerous teeth than those of the Egyptian cotton. Comparison of the Hindi bracts shown in Plate III with the Egyptian bracts at the top of Plate IV will enable these differences to be understood. Another diagnostic feature of the Hindi bracts is that the teeth run down nearer to the base, a tendency that is shared by the Hindi hybrids. Three hybrid bracts are shown at the bottom of Plate IV. The bracts of the Egyptian cotton seemed to be somewhat more cordate in Egypt than in the United States, but the narrowly triangular form, straight sides, and small teeth, remote from the base, generally render them

[a] Mutative Reversions in Cotton, Circular No. 53, Bureau of Plant Industry, U. S. Dept. of Agriculture, March, 1910, pp. 10–11.

[b] For natural-size illustrations of leaves of Egyptian and Hindi cotton, see Circular No. 42, Bureau of Plant Industry, December, 1909, pp. 4 and 5.

quite different from the Hindi bracts, in spite of endless variations in the minor details.

The calyx of the Hindi cotton has five distinctly prominent triangular lobes, one or two of which are often produced into a narrow needle-like point. In the Egyptian cotton the lobes of the calyx are very short and broadly rounded, never produced into long points. Three examples of the toothed calyx of the Hindi cotton are shown in Plate III; an Egyptian calyx and the calyx of a hybrid in Plate IV.

The fresh, newly opened flowers of the Hindi cotton have pale creamy-white petals like those of Upland cotton instead of lemon-yellow petals like Egyptian cotton. In the afternoon the flowers of both sorts change to a reddish pink, but the Hindi flowers attain a much deeper shade than the Egyptian.

The petals of the Hindi cotton are shorter than those of the Egyptian and open more widely. The Hindi flower may be described as cup-shaped, the Egyptian as tubular.

The purple spot found at the base of each petal in Egyptian flowers is lacking or only faintly indicated in typical Hindi flowers, though often quite pronounced in Hindi hybrids.

The pollen of the Hindi cotton is of a much paler yellow and the individual pollen grains are much smaller than those of the Egyptian cotton.

FRUIT CHARACTERS OF HINDI COTTON.

The bolls of the Hindi cotton have a rounded conic shape, broadest near the base, and taper abruptly to a short point. Egyptian bolls are more fusiform, narrower at the base than near the middle, and taper less abruptly to a rather blunt apex. The shape differs appreciably with the conditions, the less luxuriant plants in Egypt having a broader and more conic form than is usual in Arizona, more like the bolls produced by the Egyptian cotton in the vicinity of Los Angeles. (See Pl. VI.)

The surface of the Hindi bolls has a rather dull pale pea-green color, with only slight indications of the deeply buried oil glands. Egyptian bolls, on the contrary, have a fresher, darker color, with the surface smooth and shining, but rather deeply pitted around the numerous superficial oil glands, each of which appears as a distinct black dot. These differences appear somewhat less pronounced in Egypt than in Arizona. Pale-green bolls were found on many plants that seemed in all other respects to represent true Egyptian cotton. The darker color of the bolls in Arizona may be connected with the greater luxuriance of the plants.

The number of carpels, or "locks," varies in the Hindi cotton from 3 to 5, the majority of bolls having 4 locks. In the Egyptian cotton

the locks range from 2 to 4, with 3 as the prevailing number. Very few 4-locked bolls could be found in the Egyptian fields, but they are somewhat more numerous on the larger and more luxuriant plants grown in Arizona.

PREVALENCE OF HINDI COTTON IN EGYPT.

Familiarity with the vegetative characters of the Hindi cotton made it possible to secure definite information regarding the prevalence of this type of cotton in Egypt and thus obtain a basis of judgment regarding the value of the methods of selection that are being applied to the Egyptian cotton in Arizona. In attempting to judge of the practicability of establishing the culture of Egyptian cotton in the Southwest, it is obviously important to understand how far the commercial reputation of the Egyptian cotton for uniformity depends on the special methods of sorting and preparing the cotton for market. This will enable us to appreciate the advantage that may be gained by growing a more uniform fiber in the fields and avoiding the necessity of the subsequent labor in sorting and blending the fiber into a uniform product after it comes to the ginhouse.

Some writers have given the impression that the native cultivators rogue out all the Hindi plants during the process of thinning the young cotton early in the spring and thus avoid an admixture of the Hindi fiber. Others have referred to the Hindi cotton as a wild plant in Egypt, or even a common weed, making it seem almost impossible to avoid contamination.

Neither of these impressions seems to correspond with the facts. Though many of the native cultivators will hasten to assure the inquirer that they pull out all of the Hindi plants, a goodly remnant of typical Hindi individuals is to be found in nearly every field. On the other hand, one does not find the Hindi cotton, any more than the Egyptian cotton, outside of regularly planted cotton fields. Seeds scattered near permanent watercourses or about towns may sometimes grow to maturity, but it is not easy to understand how the idea of wild cotton growing at large in Egypt could have gained currency. Other plants that casual observers might mistake for cotton, such as the okra or bamieh (*Hibiscus esculentus*), the Deccan hemp (*Hibiscus cannabinus*), or even the cocklebur (Xanthium), are all strictly dependent upon cultivation and irrigation. It is difficult to believe that a plant of the habits of the cotton could exist as a native or truly wild species in the Nile Valley. And if such a species did exist naturally it would be dependent upon the annual flood for its water, and would be a winter-growing species. The commercial culture of cotton was not developed in Egypt under the historical system of basin irrigation direct from the annual flood

of the Nile. The period of high water comes during the late summer and autumn, the fruiting season of the cotton. Egypt did not gain importance as a cotton-producing country until the modern system of perennial irrigation from stored water was developed, in the nineteenth century.

The Egyptian system of close planting greatly increases the difficulties of finding the Hindi individuals and of counting the Hindi and Egyptian plants to determine the percentages of each. Early in the season, while the plants are still small, each one can readily be seen as a separate individual, but with larger growth they fuse together, as it were, to form a solid mass of foliage. Early inspection has the further advantage of utilizing the differences in the color of the foliage that are readily appreciable in the vegetative phase of development, but tend to disappear after the fruiting stage has been reached, as already explained.

If actual countings are not made, the proportion of Hindi cotton is likely to be seriously underestimated after the plants have reached the adult or flowering stage. It has been said that the Hindi plants can be distinguished from the Egyptian by their taller growth, but this seems to be true of hybrids or of young individuals rather than of mature plants of the true Hindi type. It was noticed at Calioub and at several other points that while many of the hybrid plants ran several inches above their Egyptian neighbors, the true Hindi plants had usually been outgrown by the Egyptian. In fact, some of the Egyptian cultivators consider that the hybrids rather than the true Hindi plants ought to be pulled out. They have noticed that many of the large overgrown hybrids produce very little fruit and are willing to pull them out so they shall not crowd their more productive neighbors. Careful roguing in the early part of the season is more likely to take out all of the true Hindi plants and leave a few of the hybrids, so that careful cultivators are more likely to be familiar with mature hybrids than with mature Hindi individuals.

The true Hindi plants, being less obtrusive when the stage of maturity is reached, are very easily overlooked unless special care is taken to separate and count the plants of each hill. Though two plants are usually left at thinning, regularity in this respect can not be depended upon. It often happens that only one plant survives, or careless cultivators may leave occasional hills with three or four plants.

It may be that the value of countings as the basis of general estimates of the proportion of Hindi cotton would not be seriously impaired by assuming two plants to each hill. The saving of time in this way would enable more extensive counts to be made. This plan was followed in a few of the later countings mentioned below.

at Calioub and Siut, in fields where the plants had grown very large. The hills were each noticed in turn to see whether they contained Hindi plants. Hills with no Hindi were assumed to have two Egyptian plants. The general effect of this plan would be to reduce somewhat the apparent proportion of Hindi plants, since it is probable that in most of the fields there would be more hills with a single plant than with three or four plants. Nevertheless, it might be that the figures obtained in this way would be more reliable, in view of the larger areas that might be inspected in a limited time.

To serve as a general basis of judgment regarding the prevalence of the Hindi cotton in Egypt, countings of individual plants were made in several different localities. In most localities several separate counts were made, usually in fields of different proprietors, or at least of different tenant cultivators. The figures obtained do not represent the full extent of Hindi contamination of the stock, for in most cases a more or less careful roguing out of the Hindi plants had already taken place. The psychological factor of the individual cultivator enters, therefore, as an important element in the calculations. One field might have only a few Hindi plants, while the next would have a considerable percentage. Thus of two adjacent fields at Tanta one showed less than 3 per cent of Hindi, the other 15 per cent.

Questioning of the native cultivators showed wide differences of individual opinion. Some of them were quite alive to the need of pulling out all of the Hindi cotton and showed annoyance or offered excuses if reminded that many Hindi plants were still to be found in their fields. Others took a more languid interest in the matter. One cultivator might claim to have pulled out large numbers of Hindi already, while his neighbor might not think it necessary to admit any responsibility for pulling out the Hindi at all. He would not deny, perhaps, that he had heard of the need of pulling out bad cotton plants, but would insist that very few people did it.

The popular impression in Egypt among people who consider themselves informed about cotton growing is that selection receives proper attention in the Delta region, where the Mit Afifi and Jannovitch, the principal varieties of Egyptian cotton, are grown, but is very much neglected in Upper Egypt, where the Ashmuni and other inferior stocks are produced. It seems, however, that this impression may relate to more careful sorting done in the ginning establishments of the Delta rather than to any really efficient selection in the field. Even about Tanta and Mansurah, the recognized centers of production of high-grade fiber, a conspicuous representation of the Hindi cotton was seen in a large proportion of the fields.

The percentages of Hindi plants counted in fields at Tanta, in Lower Egypt, are about the same as those obtained at Beni-Suef, in

Upper Egypt. (See Table I.) The idea of Hindi cotton seemed to be more common about Tanta, but no indication of a serious effort to eradicate the Hindi type from the fields could be gathered from native cultivators. They are willing to pull out the Hindi plants rather than the Egyptian at the time that the hills are thinned down to the usual two plants, but have no idea of destroying any more plants after the thinning has been done. One very zealous native showed interest to the extent of pulling up some of the Hindi plants that were pointed out to him, where there was an Egyptian plant in the same hill. But when there were two Hindi plants together in a hill he would pull up only one. Nor could he be induced to sacrifice any of the Hindi individuals that stood by themselves, although he believed (as was afterward learned) that a Government inspection was being made. The Egyptian Government sends entomological inspectors through the fields to guard against outbreaks of the Egyptian bollworm.

Beni-Suef is considered the chief center of cultivation of the Ashmuni cotton, this variety being now confined largely to Upper Egypt. Inspection of fields in this locality on June 6, 1910, showed a general prevalence of Hindi and great lack of uniformity in other respects, though not as great nor as obvious as in experiments with this variety in Arizona. There is the same tendency to red spots at the base of the leaves, which is recognized as a mark of this variety to distinguish it from Mit Afifi, Jannovitch, and other more carefully selected varieties. The more general tendency to the red spot may be a result of a more general contamination with the Hindi type of cotton.

A special count was made at Beni-Suef to learn the extent of Hindi contamination as indicated by the presence of the distinct red spot at the base of the leaf. This included true Hindi plants, obvious hybrids, and all other plants that would have been considered as having too red a callus for varieties of Egyptian cotton other than Ashmuni. Of 213 plants examined for the color of the callus 133 had the callus green or only slightly tinged with red, as usual in Egyptian cotton, while 80 plants were noted as having the callus distinctly red, as in the Hindi cotton.

In the oasis of Fayum still less attention seems to be paid to the Hindi cotton than about Beni-Suef. Native cultivators knew that some of the plants produced inferior cotton, but did not claim to be able to distinguish them except by the white flowers. There was evidently no intention of pulling out any of the white-flowered plants. The variety planted at Fayum was not considered to be Ashmuni, but was merely called Beládi, or "native," cotton.

Other countings of Hindi were made in the Beládi cotton at Siut. Cotton is not regularly planted about Siut, but experiments are

being made with seed brought from Fayum. The percentage of Hindi is much larger than appeared at Fayum, though the planter claimed that he had taken out numerous Hindi plants when the field was thinned. In addition to the plants counted as Hindi, much diversity was apparent, almost as much as in a field of Ashmuni cotton grown in 1909 at Somerton, Ariz. Such cases suggest the possibility that transfer to new conditions may have the effect of inducing additional variations in these diverse stocks, but the proportion of Hindi in either parent stock could not be ascertained. Whatever the cause of the phenomenon, it is a significant fact that the proportion of Hindi plants and obvious hybrids may run as high as 20 per cent.

The census of Jannovitch cotton at Tanta was somewhat more rigorous than that at Beni-Suef and included some plants with distinctly red leaf bases; plants with distinctly red leaves and other obviously aberrant tendencies that might have been omitted in the Ashmuni fields, where the red callus is so common a feature. But many other definitely aberrant plants with light-green leaves were not included when they lacked the red callus. These light-colored plants have the more ample and luxuriant foliage of the Hindi hybrids and may represent a second-generation splitting of the Hindi characters. Such a splitting might be expected with a color character like the basal spot that also shows seasonal reversibility.

The smallest proportions of true Hindi plants were found in fields in the vicinity of the barrage (a few miles below Cairo) and at Calioub, in the same district. None of the fields that were inspected in these places showed any large percentages. About two-thirds of the plants counted as Hindi were plants of the type considered as first-generation hybrids. In one field at the barrage and in another at Calioub no true Hindi plants could be found, even after a rather careful search, though several obvious hybrids were present in each field. At Benha, on the contrary, the Hindi percentages not only ran higher but a larger proportion of the plants represented the true Hindi type.

In the neighborhood where the counts were made near Mansurah the native cultivators placed much importance on the elimination of the Hindi plants, though they were known by a different name, "Haga," the word Hindi not being recognized. It was estimated that about 5 to 6 Hindi plants had been removed from each row of 100 to 150 plants at the time of thinning, in addition to those that remained to be counted. This would indicate a total Hindi representation of between 5 to 10 per cent in this stock of seed at the time of planting.

In several instances it was noticed that the Hindi plants seemed to be more numerous on the higher, drier ridges or dikes that bounded

the different sections into which the fields were divided for irrigation purposes. Separate counts were made of plants along some of the dikes, but without securing any definite evidence. It would be interesting to know whether such differences of conditions would have an influence over the expression of the Hindi characters. Other explanations were possible—that the higher ridges had been neglected at the time of thinning the plants or that the Hindi plants had an advantage in germinating in the drier soil of the higher ridges, because of the smooth seeds. The cotton often appears to be more luxuriant on the higher dikes than in other parts of the fields. Indeed, such dikes are usually planted with double rows of cotton, as though to take full advantage of the more favorable conditions.

TABLE I.—*Countings of Hindi cotton plants.*

Location.	Plants counted.	Egyptian type.	Hindi type.	Percentage of Hindi.
Beni-Suef, Upper Egypt (Ashmuni variety)	445	435	10	2.24
	274	242	32	11.67
	512	457	55	10.74
	165	155	10	6.06
	178	161	17	9.55
	446	435	11	2.48
	327	294	33	10.09
	245	224	21	8.56
	130	124	6	4.61
Total	2,722	2,527	195	7.16
Tanta, Lower Egypt (Jannovitch variety)	595	569	26	4.36
	886	829	57	6.43
	464	441	23	4.96
	464	437	27	5.82
	368	340	28	7.61
	1,028	923	105	10.21
	806	738	68	8.44
	134	118	16	11.92
	566	550	16	2.83
	566	476	90	15.09
Total	5,877	5,421	456	7.77
Barrage, near Cairo	1,149	1,124	25	2.17
	424	410	14	3.31
	551	543	8	1.45
	483	474	9	1.86
	567	559	8	1.41
	334	328	6	1.79
	511	486	25	4.89
Total	4,019	3,924	95	2.36
Calioub, near Cairo	417	412	5	1.19
	497	493	4	.80
	1,216	1,202	14	1.15
	2,130	2,107	23	1.07
Fayum, Upper Egypt (Beládi variety)	871	819	52	5.99
	676	629	47	6.95
Total	1,547	1,448	99	6.41
Siut, Upper Egypt	609	494	115	18.88
	467	398	69	14.77
	316	260	56	17.72
	444	354	90	20.27
	467	383	84	17.98
Total	2,303	1 889	414	17.97
Mansurah, Lower Egypt (Jannovitch and Mit Afifi varieties)	844	829	15	1.77
	476	472	4	.84
	560	555	5	.89
	531	523	8	1.50
	790	758	32	4.05
	669	662	7	1.04
	528	517	11	2.08
	598	584	14	2.34
	934	924	10	1.07
Total	5,930	5,824	106	1.78
Benha, Lower Egypt	857	810	47	5.49
	202	200	2	.99
	461	429	32	6.93
	655	633	22	3.36
	558	542	16	2.86
Total	2,733	2,614	119	4.36
Beteha, Palestine	1,043	954	89	8.53
	889	816	73	8.21
	1,975	1,947	28	1.41
	982	946	36	3.66
Total	4,889	4,663	226	4.62

Count was made of 32,150 plants in all, of which 1,733 were recorded as belonging to the Hindi type, a percentage of 5.39. If the percentages for the different localities are averaged, a somewhat higher general average, 5.98 per cent, is obtained.

One series of countings of Hindi plants was made in an experiment with Egyptian cotton in Palestine, at a locality called Beteha, near

the north end of the Lake of Tiberias, not far from the ancient Capernaum. The first two counts at Beteha were made in late-planted fields that had not yet been thinned or rogued for Hindi. The percentages obtained in these cases, 8.53 and 8.21, may be taken to represent the amount of Hindi contamination represented in the seed before planting. Early-planted fields at Beteha seemed to be as far advanced as any seen in Egypt, the date of the visit being June 23.

In order to obtain a more general and yet a not altogether indefinite indication of the prevalence of the Hindi cotton, the apparent presence or absence of Hindi cotton was noted for a considerable number of fields that could be seen to advantage from the railroad. Such inspection is greatly facilitated by a fact already considered, namely, that the leaves of the Hindi cotton have greater freedom of motion than those of the Egyptian cotton, and that they make pronounced changes of position in order to face the sun in the morning and afternoon. The Hindi plants are much more readily seen from a distance at these times than in the middle of the day, when the leaves are in a horizontal position to face the sun overhead.

The presence of tall hybrids gives a general impression of uneven surfaces to the fields and thus betrays the presence of Hindi cotton, even when details of individual plants can not be made out. But when the broader, fresh-green leaves of the Hindi plants are formed into rosettes to face the sun, they become conspicuous and unmistakable. Indeed, it is sometimes more difficult to distinguish them from the okra that is often planted in the fields than from the Egyptian cotton. The Egyptian okra (bamieh) has broad leaves of the same color as those of the Hindi cotton and also a red spot at the junction with the stem.

Such observations are greatly assisted by the fact that the Egyptian railroads are usually elevated on embankments. By being able to look down on the fields a more accurate impression can be gained than by viewing the plants from the side, as one is obliged to do when standing on the same level.

It is to be expected of course that Hindi plants would be found by more careful inspection in most of the fields where they were not apparent from a passing train. But at least it may be considered that fields showing no apparent Hindi have been rogued. In a large proportion of cases the Hindi plants and hybrids were very conspicuous. Fields that have had the Hindi plants and hybrids rogued out often appear remarkably even in height and color.

Such an inspection could not be made to any advantage after the Egyptian cotton has entered the fruiting phase, when the color changes from a dark to a lighter green, thus destroying the contrast with the Hindi cotton, so marked during the earlier vegetative phase.

In addition to the lighter color assumed by the foliage of the Egyptian plants as the season advances, the proportion of yellow in the fields is increased by the abundance of bracts and flowers. At the time these changes were taking place, about the middle of July, the dark-green tone of the vegetative phase was still shown with much uniformity in some of the fields, while others had gone over to the yellower shades or were still more completely dominated by the abundance of yellowish bracts and still yellower flowers. These changes seemed to have come rather suddenly, for most of the fields seemed to represent one phase or the other quite definitely, only a few showing pronounced individual diversities of coloring among the Egyptian plants.

TABLE II.—*Fields with Hindi cotton apparent from trains*

Fields were noted between towns—	Number of fields.	Fields with apparent Hindi.	Fields without apparent Hindi.
Calioub and Chebin el Kaneter	48	46	2
Chebin and Machetoul	53	50	3
Machetoul and Bilbeis	81	76	5
Bilbeis and Zagazig	82	81	1
Zagazig and Abou-Kebir	88	82	6
Abou-Kebir and Kafr Sakr	24	22	2
Kafr Sakr and Abou el Chekouk	30	24	6
Abou el Chekouk and Simbellaouein	51	[a](10) 44	7
Simbellaouein and Baklieh	13	(3) 13	0
Baklieh and Mansurah	24	(4) 17	7
Mansurah and Samanoud	90	(16) 73	17
Samanoud and Mehalla Kebir	29	26	3
Mehalla Kebir and Mehallet Roh	34	(4) 27	7
Mehallet Roh and Tanta	49	(3) 42	7
Total	696	623	73
Percentage		89.51	10.48

[a] In some localities fields that showed a strikingly large proportion of Hindi cotton were specially noted, and the numbers of such fields are given in parentheses in the table. It would be safe to estimate that the proportion of Hindi cotton and obvious hybrids in such fields was more than 5 per cent. Many fields between Bilbeis and Zagazig appeared to be quite as thickly sprinkled with Hindi as any in Upper Egypt where percentages of 15 and 20 were counted.

In addition to fields noted in Table II, many other inspections were made in the region between Cairo and Tanta. Several hundred fields were seen in Upper Egypt, in every one of which indications of Hindi contamination were found.

In the district between Abou el Chekouk and Mansurah much of the cotton at the middle of July was still too small and irregular to give favorable conditions for seeing Hindi plants from the train. Many of the fields had not begun to flower. In many the stand was irregular, or the plants of irregular sizes, perhaps as a result of alkali in the soil. Fields of rice interspersed among the cotton showed the same irregularity. The unfavorable conditions may be partly responsible for the larger proportion of fields with no apparent Hindi in this district. Fields with larger plants often showed great

abundance of Hindi. Most of the cotton to the west of Mansurah was in better condition and afforded a more reliable indication of the prevalence of Hindi, or rather the prevalence of roguing. Though the proportion of fields apparently clean of Hindi seemed to be distinctly larger than in other districts, many of the fields showed unmistakable Hindi plants in great abundance.

Unless the conditions are favorable for the detection of the Hindi plants such inspections could have very little value, but if made at the right time the presence of the Hindi contamination and the relative amount in different districts could be judged very easily in all localities accessible by railroad. The time would differ with the growth of the cotton in the different localities, probably extending through the month of July. Before June 20 the Hindi plants could seldom be seen from the trains, but during the second and third weeks of July they were easy to see in all except the more backward districts.

CHARACTERS OF HINDI HYBRIDS.

DISTINCTIVE FEATURES OF HYBRIDS.

Except in cases that are especially noted, the plants enumerated as Hindi in the preceding tables comprise two elements, the typical Hindi plants and the pronounced Hindi hybrids, those that resemble the first generation of the crosses that have been made between the Hindi and the Egyptian cottons.

When the fields are in the earlier vegetative phase, the pronounced hybrids can be distinguished from the Egyptian plants by the light color of the leaves and the red pulvinus at the base of the veins, almost as easily as the true Hindi. The larger size of the hybrids also attracts attention. The leaves of the hybrids become larger than those of the true Hindi plants, and most of the larger leaves have five or seven distinct lobes instead of three. The lobes of the hybrids are somewhat folded or channeled, like those of the Egyptian cotton, instead of spreading out nearly flat, as in the Hindi cotton. The larger size of the involucral bracts of hybrids is another feature usually quite obvious. (Pl. IV, *B*.) The teeth do not always run down toward the base of the bracts, as in the Hindi cotton, though there is a general tendency in this direction. In Arizona the Hindi hybrids have shown a marked tendency to sterility or to very late bearing, but in Egypt, early in June, some of the hybrids seemed to be more advanced toward flowering than their Egyptian neighbors.

The countings of the Hindi plants and obvious hybrids do not by any means indicate the full extent of the Hindi contamination in the Egyptian fields. There is background of diversity too multifarious to be counted or even noted in detail without careful inspection

of the characters of individual plants. Crossing between hybrid plants and Egyptian must produce many very dilute hybrids with little or no expression of the Hindi characters. Indeed, it may well be doubted whether any of the Egyptian stock would be found to be entirely free from the Hindi contamination if all of the ancestry could be traced. As yet we have no knowledge of the effects of slight dilutions of the Hindi blood upon the expression of characters, but experiments are being made to obtain information on this point.

Two principal elements might be recognized in the study of the diversity that exists in the Egyptian fields. One element might be ascribed to the prevalence of the Hindi cotton, the other to variation inside the Egyptian type. But in the present state of our knowledge it is often quite impossible to determine at once whether a variant plant is a dilute Hindi hybrid or an unusual example of the Egyptian stock. Evidence on this question can be secured by planting the seed to see whether the progeny "come true" to the characters of the parent, as in a mutation, or show more pronounced reversions to the Hindi type. But many mutative variations are also to be considered as reversions. The practical fact is that the Hindi contamination is responsible for a large amount of diversity outside of the obvious hybrid forms that resemble first-generation crosses.

Among the plants enumerated as Egyptian are many that are appreciably different from the Egyptian type, even in the early part of the season. Without departing seriously from the Egyptian form and habits of growth, some of the plants have broader or narrower leaves, lighter or darker than their neighbors. Though the form of the leaves may be that of the Egyptian cotton, the bases of the veins may be reddened as in the Hindi. Or plants with Egyptian foliage may have unusual habits of growth, the more frequent tendency being toward taller stalks and more strictly upright branches.

The large cordate bracts that characterize the most obvious Hindi hybrids are not entirely confined to that class of plants, but may be found on other large plants with foliage of Egyptian shape and color. The pulvinus may have the Hindi size, shape, and color, though concealed by more abundant hairs. In addition to the large circular, or very deeply cordate bracts, with the teeth running well down, such plants often have the calyx distinctly toothed, though the teeth do not have the long slender points that occur so frequently in the Hindi cotton. (See Pls. III and IV.)

As the season advances such differences become more apparent. When flowering and fruiting begin the hybrid nature of many individuals becomes unmistakable, even in plants that might not have been suspected of hybridity from the vegetative characters alone. Roguing must not be limited to the time of thinning in the early

spring if any complete elimination of the Hindi characters is expected.[a]

The tendency to revert to small bolls is one of the most frequent and least obvious evidences of Hindi contamination. Small bolls can often be found on large-bolled plants, but many individuals produce only small bolls. The shape of the bolls may not suggest Hindi, though other Hindi characters may be found, such as naked seeds, sparse white lint, or pale spots in the flowers.

To make a complete enumeration of all the plants that show any of the Hindi characters it would be necessary to watch a field of cotton through the whole season, for in some plants only the lint and the seeds may betray the Hindi ancestry. Already, at the beginning of the fruiting season in Egypt, it became evident that many of the aberrant Egyptian plants were really Hindi hybrids, in addition to the type of hybrids that had been included in the countings. Even in the fields that had been quite carefully rogued, as at Mansurah, so that only very small percentages of plants with the Hindi foliage were left, many white-flowered individuals remained. The leaves of the white-flowered plants seemed to be a little broader than those of adjacent yellow-flowered Egyptian plants, but the difference was not enough to be noticed if attention had not been attracted by the flowers.

COHERENCE OF CHARACTERS IN HYBRIDS.

It is not yet certain that all of the more Hindi-like hybrid plants are really first-generation hybrids, the direct result of cross-fertilization between Hindi and Egyptian plants. All that is known at present is that the crossing of Egyptian with Hindi does produce plants of the Hindi-like hybrid type. The experiment has been made in Egypt by Mr. Balls and in Arizona by Messrs. McLachlan and Meade. It is possible, however, that some of the Hindi-like hybrid forms may represent the progeny of hybrid parents. According to the Mendelian theory of heredity a part of each generation of hybrids should resemble the first generation, while the remainder should show other combinations of the parental characters. In typical Mendelian hybrids the contrasted parental characters are supposed to have entire freedom of chance combination in the second and later generations.

In reality there does not seem to be such complete freedom of combination of the two sets of characters that represent the two parental types. Plants that have the Hindi foliage, or that of the Hindi-like hybrid type, invariably have the white petals of the Hindi cotton.

[a] Cotton Selection on the Farm by the Characters of the Stalks, Leaves, and Bolls, Circular No. 66, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

White flowers always have the more open, cuplike form of the Hindi cotton instead of the longer and more tubular form of the Egyptian cotton. It very rarely if ever happens that any single Hindi character is brought into definite expression by itself—that is, without being accompanied by the more or less definite expression of other Hindi characters. It is hardly to be supposed that any of the Hindi plants, any more than the Egyptian, are pure bred in the sense of having had no Egyptian ancestors, and yet the Hindi type is nearly as uniform as the Egyptian, in spite of all the selection that has been directed against it. Neither is it reasonable to assume that all of the pronounced hybrid plants have the same proportions of Hindi and Egyptian blood, though they form nearly as definite a group as the parent types.

Hindi-like lint and seeds sometimes occur on plants that give little or no external evidence of Hindi contamination, but plants that have previously shown Hindi leaves or flowers very seldom, if ever, have typical Egyptian bolls or lint of good Egyptian quality. In a field of Jannovitch cotton raised in Arizona in 1909 from imported Egyptian seed numerous individuals were found that seemed, early in the season, to depart from the normal Egyptian type only in the lighter and more pinkish tinge of the purple spot at the base of the petals. But when these plants were examined again in the fall it was found that the bolls and lint also departed from the type of the variety. All the pale-spotted individuals had small bolls, and some of them showed naked seeds and short Hindi-like lint.

That the depth of color of the petal spot can be, in itself, a matter of any direct significance in the economy of the plant is hardly to be believed, but it seems to have an indirect significance as indicating a tendency for the Hindi or other abnormal characters to come into expression. White petals may be considered in the same way as evidence of a still stronger tendency to express the Hindi characters in the parts to be subsequently formed. Very pale yellow flowers were noticed on a few Egyptian-like plants at Mansurah, but in nearly all cases a departure from the normal Egyptian color involved a complete change to the creamy white of the Hindi flowers.

Although white Hindi-like flowers are rarely to be found on plants that have produced Egyptian foliage, such sudden changes in the expression of the characters do not appear to be normal phenomena of heredity, at least in cotton hybrids, for plants with these incongruous combinations of characters are generally infertile and sometimes completely sterile.[a]

[a] Mutative Reversions in Cotton, Circular No. 53, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, p. 6.

Coherence of characters is not confined to Hindi hybrids, but apparently has to be reckoned with in any attempt to combine the characters of different types of cotton. The phenomenon was first recognized and described in the study of Egyptian-Upland hybrids in Texas and Arizona. It differs from correlation in affecting whole groups of characters instead of only two or three. Thus a general correlation may be said to run through many different types of cotton—between the shape of the boll and the length of the lint or between the color of the lint and its strength. Correlation refers primarily to the fact that certain characters tend to vary together, one increasing or diminishing in relation with another. The fact that the weight of ears of corn increases with their length is reckoned as a correlation. Coherence refers to the expression of characters in hybrids. It denotes a condition in which characters derived from the same parent remain together in expression instead of being expressed in chance combinations as in Mendelian hybrids.

Correlations often appear entirely arbitrary, unless they are merely mathematical expressions, as in the case of the corn ears. From the mathematical standpoint it seems impossible to understand why long fibers should not be packed into round bolls as well as into pointed bolls or why brown fibers should not grow as long as white fibers. But after the tendency to coherence of much larger groups of characters has been recognized as a fact correlations appear somewhat less mysterious. The general association of longer lint with more pointed bolls in any particular type of cotton may be connected with the other general fact that the long-linted types of cotton have more gradually tapering bolls than short-linted types of cotton. Coherence implies that the expression or nonexpression of one character may determine whether other characters shall be patent or latent.

A striking example of coherence of characters was observed in Egypt in a block of hybrids made by Mr. F. Fletcher, director of the School of Agriculture at Gizeh, between an American Upland variety called Jackson's Limbless and an Egyptian variety called Voltos, somewhat similar to Nubari, Voltos being the male parent. In addition to many other courtesies of hospitality Mr. Fletcher most generously insisted upon a full use of his interesting series of experimental plantings of cotton at Gizeh, which yielded many interesting facts with special relation to problems of diversity.

Instead of the usual tendency of some of the Egyptian traits to predominate in the first generation, this lot of hybrids showed an unusually definite expression of the Upland characters. Very few of the plants would have been taken for Egyptian cotton, even on casual examination, and none of them showed any close approximation to the Egyptian type. On the other hand, a considerable proportion of the plants adhered very closely to the characters of the

Upland type. Several of these were distinctly clustered and some were quite limbless, like the Upland parent, though the majority did not have the shortened internodes.

Coherence of characters was shown very conspicuously in the fact that all of the definitely clustered or limbless plants had the Upland type of foliage, all were quite hairy, and all had white petals, as in Upland cotton. The only definite mark of hybridization on several of these plants was the purple spot at the base of the petals. When the purple spot was lacking there was no definite evidence of hybridization, but some plants that would have been taken for pure Upland in all other respects had very faint spots, showing that they were hybrids.

There was no complete dominance of the yellow flower color as reported in some Egyptian-Upland hybrids. None of the yellow flowers were as yellow as those of Egyptian cotton. All of the yellow flowers had pale-purple spots at the base of the petals. Some of the white flowers had spots as dark as any of the yellow flowers. In this respect the hybrids may be said to afford an example of the Mendelian law of free combination, but these variations occurred in the first generation, where Mendelian crosses are expected to give more uniform results.

Another lot of hybrids produced by Mr. Fletcher by fertilizing an Upland cotton from Cochin China with pollen of the Voltos variety of Egyptian cotton showed quite a contrast in comparison with the preceding series. Nearly all of these plants looked like ordinary first-generation Upland-Egyptian hybrids, except one that showed only Upland features. But the white petals had small purple spots as an evidence that the plant represented a true hybrid, not merely a result of accident in manipulation. The plant was very hairy and the leaves and bolls showed no departure from Upland characters. All other plants of the cross had pale-yellow flowers, and all the flowers had the spots pale, sometimes entirely wanting. The spot character would have to be reckoned as nearly recessive, but not quite completely so. Two plants were found in the same lot that might have been taken for ordinary Egyptian individuals, unless it were for too much hair, but one plant was more hirsute than the other, especially on the under side of the leaves, where the stellate hairs developed into noticeable tufts. This also must be taken as a sign of hybridity. The other plant was somewhat abnormal, in that it produced several sterile involucres composed of only a single bract.

In a third lot of hybrids between the Voltos variety of Egyptian cotton as the female parent and the Cochin China Upland as the male there were several more plants of a complete Upland type. Three of these plants had been grown from fuzzy seeds that appeared in the Voltos cotton, an indication that the variety was not pure.

The habit of these plants was much like the Cochin China parent and also closely similar to that of the Rabinal and Pachon varieties of Upland cotton from Central America. The plants were very hairy and the bracts were unusually well closed, as well or better than in the Rabinal cotton, and being also larger they remained closed to a more advanced stage. This character of the closed bracts was also shown among the hybrids. It was fully expressed, or even intensified, in some of the plants that had yellow flowers and other unmistakable evidences of hybridity. Well-closed hairy bracts have value as a weevil-resistant character, since they exclude the insects from the young buds.[a]

The phenomenon of coherence of characters is not only of interest from the standpoint of the scientific study of heredity, but is of distinct practical importance in relation to the problem of developing and maintaining uniformity in cultivated varieties. It represents on the one hand a limitation of the power of the breeder to make free combinations of the characters of different species, as in ordinary Mendelian hybrids, but on the other hand it assists in maintaining the uniformity of established strains and guarding them against contamination. If there were no coherence in the expression of the characters any Hindi character could come into expression independent of any other. The work of selection would involve a detailed inspection of each plant by all of its characters and would require an amount of time that would make it entirely impracticable as a farm operation, even though the farmer should acquire the necessary skill. In short, it is the fact of coherence of characters that lends value to selection, that makes it possible by roguing to improve or maintain the quality of the crop.

The success of the Egyptian method of securing commercial uniformity by matching the color of the fiber rests also on the fact that variations in the color of the lint are not independent of other characters. The inferior lint of the Hindi plants and hybrids does not have the same color as the lint of Egyptian plants. If there were no coherence of the Hindi characters the brown color would be found in combination with the naked seeds and short lint of the Hindi type, but this seems never to occur.

Recognition of the principle of coherence calls attention to the practical fact that plants seldom make serious changes in the expression of one character without showing changes of expression on other characters. The plants that produce the inferior lint in the fall are those that have departed from the regular courses of development earlier in the season. Indeed, these departures from normal heredity

[a] Weevil-Resisting Adaptations of the Cotton Plant, Bulletin No. 88, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1906.

can usually be recognized much more readily by inspecting the vegetative characters of the plants in the earlier stages of development than after the crop is ripe and the damage of cross-fertilization has been done. It takes only an instant to see that the foliage or the habits of growth of a plant are different from those of its neighbors, much less time than is required to judge plants by their lint and seed characters at maturity, after the external differences of leaves, flowers, and bolls are no longer to be appreciated.

The breeder in search of new varieties may find it desirable to preserve all the sports or freak plants that he can find to see whether in some rare cases they may not prove superior to normal plants of the variety, but the farmer who follows this course will lead his variety to degeneration. He must rely on the fact that the vast majority of the plants that diverge from the characters of the variety represent degenerations. His policy is to pull all the aberrant plants as soon as they can be detected. If allowed to remain, they will destroy the uniformity of the stock.[a]

INTENSIFICATION OF CHARACTERS IN HYBRIDS.

Another deviation from the Mendelian expression of characters in cotton hybrids is found in cases where characters are suppressed or intensified beyond the range of variation of the parental types. The crossing of the Egyptian cotton with short-staple Upland varieties

[a] A writer in the Liverpool Daily Post and Mercury (Saturday, March 12, 1910) maintains that periods of prosperity for the Egyptian cotton industry have followed the introduction of new varieties and that periods of depression ensued as the varieties degenerated:

"It is to be remarked that each time a new variety of seed was sown for the first time of cultivating an increase was immediately obtained of 1 to 1½ cantars weight per feddan, and as high as 12 to 14 per cent in the ginning yield. This increase diminished with the passing years and by slow degrees the seed degenerated. The excellent results of the beginning did not bear out their early promise, and after a lapse of time of more or less duration the seed cultivated had to be abandoned to give place to a new variety. * * *

"And it is the same story. As in 1862, when the Jumel, old and degenerated, had to be abandoned, as in 1892 the Ashmuni had to be replaced by Mitaffifi, so to-day the Mitaffifi seems coming to the end of its career, and no one can deny the degeneration of quality.

"While in 1891, 1892, and 1893 it yielded 7 to 8 cantars per feddan on the best lands and 5 to 6 on the others, at the present day it hardly gives either 7 or 8 cantars, and in Lower Egypt its production has certainly diminished by 1 to 1½ cantars per feddan on an average. This cotton, which during the first years of its cultivation yielded 110 to 114 in ginning, no longer gives to-day more than 101 to 103, and that with difficulty.

"Seventeen years, therefore, had sufficed for the degeneration of Jumel, and it is exactly after the same lapse of time that we are forced to notice the degeneration of Mitaffifi."

usually results in a favorable intensification of the lint characters in the first generation. Notwithstanding the inferiority of the lint of the Upland parent, the lint of the hybrid is usually longer and stronger than that of a pure Egyptian progeny grown under the same conditions.[a]

A form of intensification occasionally shown in Egyptian-Upland hybrids is an unusual development of the nectaries. An excellent example of this was found in an aberrant plant at Calioub, July 12, 1910. It was probably a Hindi hybrid, though showing no pronounced Hindi characters. It was much taller than its neighbors and had unusually long basal internodes on the fruiting branches, while the other internodes were short and imperfect. Many buds had aborted and no bolls had been set. Each of the involucres that remained on the plant, 15 in number, had a large nectary on each of the three bracts.

In order to give a more definite indication of the extent of intensification shown by the nectaries of this plant, notes were made of the occurrence of nectaries on the involucral bracts of six adjacent plants, one of which happened to be Hindi. The lower buds of the Egyptian plants were generally without nectaries, unlike the Hindi plant which had nectaries on the early as well as on the later involucres, though with no such regularity as in the aberrant plant, to say nothing of the much larger and more regular size of the nectaries of the aberrant plant. Table III shows the distribution of nectaries on all the involucral bracts of the Egyptian and Hindi plants. Bracts with large nectaries are indicated as "N," those with small nectaries as "n," those with no nectaries as "o." No nectaries as large as those of the aberrant plant were found on any of the neighboring Egyptian and Hindi individuals. Several other plants were examined in addition to those that were definitely counted. One of the Egyptian plants had an involucre with only two bracts, a not uncommon occurrence.

[a] Suppressed and Intensified Characters in Cotton Hybrids, Bulletin 147, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909.

TABLE III.—*Census of nectaries of Egyptian and Hindi cotton plants.*

Adjacent plants.			Aberrant plant.	Adjacent plants.		
Egyptian.	Egyptian.	Egyptian.		Hindi.	Egyptian.	Egyptian.
o n o	o n n	o o o	N N N	o o o	o o o	o o o
o o o	o o o	o o o	N N N	o o o	o o o	o o o
o o o	n n n	o o o	N N N	o n n	o n o	o n o
o o o	n n n	o o o	N N N	n n o	o o o	o o n
		o o	N N N	n n o		n o o
		o o o	N N N	o o o		o n n
		o o n	N N N	o n o		o o o
		o n n	N N N	o o n		o o o
		n n n	N N N	n o n		o n n
		o o n	N N N			
		o n o	N N N			
			N N N			
			N N N			
			N N N			
			N N N			

Another example of a notable departure from parental characters was shown in a block of hybrids produced by Mr. Fletcher by crossing two Egyptian varieties. The whole block showed a remarkable susceptibility to a disease of the roots similar to the wilt of the United States. The whole block of plants was notably different in behavior from either of the three other blocks of hybrids that inclosed it on three sides; the other side bordered on a roadway. All of the plants were small, with a very open habit of growth, and their foliage was tinged with red. Many of the roots were dead or dying and had changed to a grayish-brown color. The contrast between this block and its neighbors was very distinct out to the square corners, with the larger and more healthy plants on either side.

Microscopical examination by Mr. Fletcher found the fibro-vascular bundles of the roots stuffed with fungous mycelium. There seemed to be no escape from Mr. Fletcher's view that this particular stock of hybrids was unusually susceptible to the disease in comparison with the surrounding stocks. The peculiarity may have come, of course, from one of the individual plants that happened to be used as parent of the cross, but this does not diminish the value of the evidence that some members of the Egyptian type may have marked susceptibility to the disease. Mr. Fletcher has noted other indications of such susceptibility and is inclined to believe that the

disease may be an unrecognized cause of much damage to the crop. It appears that the symptoms are generally more pronounced on land that had cotton the year before, but the observations have not extended far enough to establish this point.

RELATIONSHIPS OF HINDI AND EGYPTIAN COTTONS.

The Egyptian cotton in the United States is exposed to the additional danger of crossing with the American Upland type of cotton. It is quite as important to guard against this danger as to exclude the Hindi contamination that has caused so many difficulties and losses in Egypt.

Experiments indicate that the result of allowing the Egyptian cotton to be crossed with Upland pollen will be much the same as with the Hindi, and this is also to be expected from the fact that the Hindi cotton shares many of the characters of Upland cotton, and especially those of some of the types of Upland cotton that have been discovered recently in southern Mexico and Central America.[a]

Though differing in minor details, there is a general agreement between the American Upland types of cotton and the Hindi in the habits of growth, the form, color, and textures of the leaves, involucres, and flowers. The external characters of the bolls are also much the same. The principal difference lies in the character of the seeds. In the American Upland cottons the seeds are generally covered with a dense coat of short fuzz, though some of our varieties show frequent variations in the direction of naked seeds, like those of the Hindi cotton. Indeed, there are occasional variations where the lint and the fuzz are both lacking, showing that the seed characters of the Hindi cotton lie within the range of variation of the Upland type. Thus if the parentage of a hybrid plant is not known it may be impossible to determine whether it represents the Hindi contamination or an Upland cross. In general it may be assumed that plants with hairy stems and leaves represent Upland hybrids rather than Hindi, for the typical Hindi cotton is not hairy. Yet a few hairy Hindi-like plants have been found in Egypt as well as in plantings of imported seed in Arizona.

From the standpoint of the study of heredity it would be very desirable to determine when the Hindi contamination of the Egyptian cotton took place. The Hindi variations may represent a recent admixture or the crossing may have taken place so far back as to represent a general constitutional tendency to reversion pervading the whole Egyptian type. The idea that the Hindi cotton grew as a wild weed in Egypt would allow us to suppose that the process of

[a] Origin of the Hindi Cotton, Circular No. 42, Bureau of Plant Industry, U. S. Dept. of Agriculture.

contamination had been continuous, with some new crosses every year to replace those that were removed by selection. But the idea of wild cotton in Egypt and also the theory founded upon it seem altogether improbable. The sources of the Hindi contamination must apparently be sought farther back.

Another possibility is that the Hindi cotton was formerly cultivated in Egypt before the present so-called Egyptian type was introduced and that the mixing occurred while the Egyptian cotton was replacing the Hindi. A difficulty with this idea is that the lint of the Hindi cotton is so sparse and short as to make its cultivation seem improbable. But it is possible that Hindi plants now appearing as reversions among the Egyptian cotton do not fully represent the possibilities of the Hindi type in the direction of lint production. While there is a general tendency to sparse lint among naked-seeded types of cotton, this is not universal. A strain of Caravonica cotton grown in Hawaii has very abundant lint, in spite of the fact that the seeds are entirely devoid of fuzz, as shown by samples recently deposited with the Department of Agriculture by Dr. E. V. Wilcox, Director of the Hawaii Agricultural Experiment Station. Mr. Fletcher has recent information indicating that Hindi cotton is still planted as a crop in Mesopotamia under the same name as in Egypt. Plants grown at Gizeh by Mr. Fletcher from seed received from Mesopotamia were carefully examined and seemed to show all the essential characters of the Hindi cotton. (See Pl. III.) It is possible, therefore, that the Hindi admixture may be traced by way of Mesopotamia.

The idea that the Mediterranean countries were limited to Old World types of cotton (*Gossypium herbaceum*, and its relatives *indicum*, *arboreum*, etc.) even in ancient times may prove to be erroneous. In southern Italy an Upland-like cotton is cultivated under an ancient name "*bombage*," evidently cognate with the Greek "*bombax*." The plants are quite small and somewhat hairy, like American Upland cotton, but the bracts are very strongly toothed after the Hindi fashion.

In this connection it may be well to mention the fact that a sample of seed of brown, rough-fibered cotton has recently been received from northern Arabia by the United States Department of Agriculture. While these seeds and lint do not closely resemble those of any recognized variety, they show more of an approach to the Egyptian qualities than any samples previously seen from the Old World. Another small sample of seeds and lint, received about the same time from Honduras, has a much closer resemblance to the Egyptian cotton and is stated to represent a native tree cotton. These seeds have the size and shape of Egyptian seeds with tufts of brownish

fuzz at the ends, and the lint is similar to that of the Egyptian cotton, whereas the seeds from Arabia are covered with a brown fuzz.

While at Gizeh there was also opportunity, through the kindness of Mr. W. Lawrence Balls, botanist of the Khedivial Society, to see living plants of a kidney cotton raised from seed brought from the Niam-Niam country in the upper valley of the White Nile, a type considered by Mr. Balls as representing one of the parents of the Egyptian cotton. It has to be admitted that these plants show a notable agreement with the Egyptian cotton in many respects and are quite unlike any of the varieties of kidney-seeded cotton that have been seen in Mexico and Central America or received from those countries.

The Niam-Niam cotton has three external nectaries present with great regularity, reniform-cordate in shape, and usually distinctly emarginate on the upper side. The nectaries are always of a red color, at least on these well-exposed plants. Inner nectaries are also present with much regularity, are broadly V shaped, and often colored red. The surfaces of the nectaries are rather coarsely granular-papillate and without hairs. Cases of supposed intensification of nectaries in Egyptian hybrids might be considered as reversions to such an ancestor as this.

The leaves vary from entire to 5 lobed, the latter usually on the rank growth of new shoots. Occasionally there are 6 or 7 lobes, but the additional lobes are usually small. The leaves are of the Egyptian form and color, somewhat more hairy than usual in Egyptian cotton, but the hairs are short, as in some variations of the Egyptian type. The pulvinus and veins are green or tinged with dull reddish, as in Egyptian cotton. The pulvinus is very hairy and not enlarged, but the outer pairs of veins show an occasional tendency to unite at the base. There are 1 to 3 leaf nectaries, those of the midribs being sagittate.

The stipules of the main stalk and vegetative branches are long and slender as in rank-growing Egyptian cotton, while those of the fruiting branches are unequal, one narrow and the other broad, the latter often with two teeth.

The bracts are usually connate at their base for one-eighth to one-fourth inch, as often occurs in Egyptian cotton. The calyx has very distinct, broadly rounded lobes (Pl. V, *C*), more prominent than is usual in the Egyptian cotton but nearly equaled under some conditions, as in the Egyptian cotton grown near Los Angeles in the season of 1909.

The plants at Gizeh were quite woody and about 10 feet high, and had no tendency to produce elongated fruiting branches. Only one flower was borne on each fruiting branch. The pedicels of the flowers

were very short and subtended by a small leaf, usually with one stipule very much enlarged and often toothed, somewhat like an involucral bract.

One of the most striking peculiarities in which the Niam-Niam cotton agrees with the Egyptian is the tendency to enlargement of one of the stipules of the leaves of the fruiting branches. It has been noticed in Arizona that abnormally large strong-growing plants of Egyptian cotton often have this tendency very pronounced, a fact suggestive of the possibility that such plants may represent reversions toward an ancestral form similar to the Niam-Niam cotton. The unequal development of the stipules has been considered in relation to Hindi hybrids, but such a tendency does not seem to be as pronounced in the Hindi hybrids as in the Egyptian cotton and in this African relative. Enlarged stipules are especially likely to be found in Egyptian cotton on leaves of short branches produced from the fruiting branches and may be connected with the tendency of such branches to produce organs intermediate between the ordinary leaves and the involucral bracts.

While the Niam-Niam cotton must certainly be considered in the study of the relationships of the Egyptian cotton, it seems more likely to prove a collateral relative than a direct ancestor. It is very difficult to believe that the Egyptian cotton descended from a kidney-seeded ancestor or from one that had the fruiting branches so shortened and specialized as the Niam-Niam cotton.

The most significant thing regarding these cottons from Mesopotamia and central Africa is that they may add something to the evidence of the existence of genuine Old World varieties of the Upland type of cottons. The Upland variety from Cochin China recently brought forward by Mr. Fletcher as an ancestor for our American Upland cottons is also very interesting from this standpoint.[a]

As seen growing at Gizeh the Cochin China cotton shows a remarkable resemblance to some of the Central American varieties and especially to two types from the Central Plateau and the Pacific slope of Guatemala, those that have been described as Pachon and Rabinal. The Guatemalan Upland cottons and other related types from southern Mexico show very close agreements with the Hindi cotton in so many of the characters that a rather close relationship must be supposed to exist. This renders the close resemblance of the Cochin China cotton to the Central American varieties all the more interesting.

The Cochin China cotton shows in Egypt the same bushy habit of growth with many upright vegetative branches as the Central Ameri-

[a] Fletcher, F. The Origin of Egyptian Cotton, Cairo Scientific Journal, vol. 2, no. 26, November, 1908.

can Upland cottons when first brought to the United States, though not carried to quite the same extent under the less extreme Egyptian conditions. The stems, leaves, and involucres are densely hairy as in the Central American cottons. The bracts also have the margins hairy and very firmly appressed in the same way as in the Central American cottons and perhaps to an even greater extent.

The lobes of the calyx have the same tendency to grow into long teeth (Pl. V, *A*), and the bolls have the same conic-oval, abruptly apiculate form which several of the Central American varieties share with the Hindi cotton. In short, the resemblance seems so complete that if the Cochin China cotton had been found in Central America it would have been considered as only one more of the relatively slight local variations shown by the general type represented by the Rabinal and Pachon varieties. The most notable difference was an apparent absence of bractlets, but this condition could probably be found on second-year wood in the Central American varieties. While the Cochin China cotton, like the Central American varieties, appears to be a relative of our American Upland cottons, there are native Mexican varieties that seem to be still more closely related to some of our United States Upland varieties. Yet it is not impossible that Mr. Fletcher's idea of tracing the Cochin China cotton to the United States through an early introduction of so-called "Siam cotton" may turn out to be true of our long-staple Upland type still grown in Louisiana.

If the Cochin China cotton were more nearly identical with our United States Upland cottons it might be looked upon as an introduction from the United States, but it is much less likely that a local Central American variety has been carried to Cochin China. The information of Mr. Fletcher's correspondent, that this cotton was really indigenous in Cochin China, may therefore be credited.[a]

While the existence of these additional relatives of the Egyptian and Hindi types of cotton in the Old World does not affect the evidences of relationship that have been pointed out between these types of cotton and others that appear to be natives of America, it does have a bearing upon the question of how these members of American types of cotton reached the Old World. If many sorts like the Hindi, Egyptian, Niam-Niam, and Cochin China cottons are found in different parts of the Old World it will not be reasonable to believe that they represent recent importations from America, since the time of Columbus. It will be necessary to consider the possibility that American types of cotton, like the coconut palm, sweet potato, and

[a] Fletcher, F. The Botany and Origin of American Upland Cotton. Cairo Scientific Journal, vol. 3, no. 38, November, 1907, p. 263.

other economic plants of American origin, were carried across the Pacific Ocean in prehistoric times.[a]

If our long-staple varieties of Upland cotton originated in the East Indies it is reasonable to expect that other superior types of Upland cotton may be found in that part of the world. Indeed, Mr. Fletcher's Cochin China cotton seems to be a promising type, worthy of attention from the standpoint of acclimatization. The bolls are larger than in our long-staple Upland varieties and the lint is of good length. The very large and well-closed hairy involucral bracts would have value from the standpoint of weevil resistance, like the similar bracts of the Central American varieties which exclude the boll weevils from the young buds, as already noted in describing the hybrids of the Cochin China cotton.[b]

SUPPOSED INCREASE OF HINDI COTTON.

The popular belief in Egypt is that the proportion of Hindi cotton is increasing, though there seems to be no way to obtain definite information on this point. Intelligent natives declare that they

[a] Food Plants of Ancient America, Smithsonian Report 1903, pp. 481–497.

Agricultural History and Utility of the Cultivated Aroids, Bulletin 164, pt. 2, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

History of the Coconut Palm in America, Contributions from the United States National Herbarium, vol. 14, pt. 2, 1910.

[b] The successful cultivation of a so-called "Cambodia" cotton in British India has been noticed in a recent Consular Report, issued while this bulletin was in preparation. The facts are of special interest in view of the many unsuccessful experiments that have been made in India with Upland varieties from the United States. The statement is as follows:

"In Tinnevelly district, Madras Presidency, at the extreme southern end of the peninsula, there had been planted up to October about 17,000 acres in what is known as Cambodia cotton. This is a variety of acclimatized American cotton, introduced into the country about four years ago, which is being quite successfully grown and which yields far more fiber per acre than any of the old varieties.

"Last year a total of 15,000 bales of Cambodia was produced on 15,000 acres of the black soil of Tinnevelly, and this season, in addition to the larger area already reported as planted in that district, the agricultural department is experimenting with it in several other parts of the Presidency with a view to its general adoption by growers. It is said to thrive on irrigated lands, and should it prove even partially as successful in other districts as in Tinnevelly, there is little doubt that within a very few years it will be grown throughout the whole of south India, if not elsewhere in the country.

"As the fiber of the Cambodia compares favorably with that of American Upland cottons, it is not too much to say that India may within a few years become a serious competitor of the United States in meeting the world's demand for the commodity, instead of furnishing only the inferior grades as at present." (*Report of Nathaniel B. Stewart, consul at Madras, India, in Daily Consular and Trade Reports, December 17, 1910.*)

remember when the Mit Afifi or the Jannovitch varieties produced fields of uniform plants, all of the same height, with none of the irregularities now shown by the tall hybrid plants of the Hindi-infested fields. But in the absence of any actual countings in former years it is not possible to determine what change has taken place.

From the standpoint of the Mendelian theory of heredity an increased representation of the Hindi characters would not be expected to occur unless additional contamination took place from outside sources, which appear to be lacking in Egypt. Mathematicians have shown that characters expressed according to the Mendelian theory would not tend to increase, but would remain at the same general proportion in a mixed population.[a]

Nevertheless, an increasing dominance or stronger tendency of expression of the Hindi characters should not be dismissed as impossible, for it has been noticed in experiments with Egyptian-Upland hybrids that the Upland characters seem to attain a more and more predominant expression in the later generations, even when selections are made with a view to preserve the Egyptian or intermediate characters among the hybrids. Though no direct statistical evidence regarding the supposed increase is likely to be obtained, it may be possible to throw light on the question indirectly by the study of the tendencies of expression shown in artificial hybrids between the Egyptian and Hindi types. Experiments of this kind were begun by the making of such hybrids in Arizona in the season of 1909.

The popular impression of a gradual increase in the proportion of Hindi cotton is supported by the general opinion of the commercial world that the quality of the Egyptian cotton is declining. This may mean that poorer qualities are being sent out under the same marks or that the ginning establishments are finding it more difficult to keep their product up to recognized standards. Either of these results, or both, might naturally be caused if the Hindi cotton continues to multiply in the face of the selection that is now being applied.[b]

Considered on a percentage basis, a considerable amount of selection has undoubtedly been directed against the Hindi cotton. In

[a] Hardy, G. H. Mendelian Proportions in a Mixed Population. Science, n. s., vol. 28, p. 48, July 10, 1908.

[b] The idea of a progressive deterioration of the Egyptian product is confirmed by a recent authoritative statement published while the present report was in preparation: "There is no gainsaying the unanimous evidence that the general character of Brown Egyptian cotton [by which Lancashire means Afifi] has gone down most markedly from the standard of 15 years ago. All the spinners of fine counts, to whom strength is everything, speak with regret of the Afifi of those days. Without exception they say that during recent years they have continually been compelled, in order to maintain their standards of strength,

the Delta region a large proportion, probably 50 per cent or more, of the Hindi plants that germinate in the fields are rogued out. The sorting of the fiber in the ginhouses must take out a still larger percentage of the Hindi cotton that is harvested.

Some of the ginners are also said to sift out the smooth seeds, or even to resort to hand picking to keep the smooth Hindi seeds from being planted. While it is to be expected that the various ginning establishments would be found to differ greatly in the thoroughness with which these precautions are observed, the general effect must be to exclude a large proportion of the Hindi seed every year. Under any Mendelian rule or other customary idea regarding the effects of selection it might be expected that the expression of the Hindi characters would have declined long since to a negligible quantity, but the facts certainly do not correspond to this expectation. The result demonstrates instead that the system of selection now in operation is entirely inadequate to eliminate the Hindi variations.

As already noted in connection with the seed characters of the Hindi cotton, the tendency to an increased representation of this type is not limited to the factor of prepotency, but may prove to be due partly or wholly to more prompt germination of the seeds, owing to the absence of fuzz that allows more effective contact with the soil. Experiments with other types of cotton have shown that varieties having less fuzz germinate more promptly, but comparisons will also be made between Egyptian and Hindi.

ESTIMATE OF DAMAGE FROM THE HINDI CONTAMINATION.

As the percentages of Hindi cotton in the Egyptian fields do not represent the full amount of Hindi contamination, so they do not indicate the full extent of damage to the crop. In addition to the true Hindi plants and the obviously Hindi-like hybrids, supposed to represent the first generation, more careful inspection always shows a considerable number of obscure or dilute hybrids as well as many individual variations that may reasonably be ascribed to the same general fact of Hindi contamination. These aberrant plants include those that show the white flowers, the flowers with pale spots, and other peculiarities that can often be detected only by

to raise the mark or grade of cotton they use, and to add increasing proportions of superior varieties, such as Nubari and Jannovitch, merely to obtain the same results as they formerly secured with Afifi alone. Strength is absolutely essential in the manufacture of 'twist' yarns for warping, and in spite of improved spinning processes, greater loss in waste through taking out a larger proportion of short staple, and more careful and costly methods generally, the spinners have had the greatest difficulty in maintaining the quality of their yarns." (See Todd, John A., "The Market for Egyptian Cotton in 1909–1910," L'Egypte Contemporaine, no. 5, January, 1911, p. 5.)

careful comparison of all the parts, including the seeds and lint. A complete census of the aberrant plants of a field requires too much time to make it generally feasible. Moreover, the cotton in Egypt was not yet far enough advanced in July, 1910, to allow such a study to be completed. The visit was made at that season because the vegetative characters of Hindi plants were known to be more readily visible at that time.

Counts made in a field of Ashmuni cotton raised in Arizona in 1909 from imported seed gave over 40 per cent of the plants showing distinct departures from the normal characteristics of Egyptian cotton, mostly in the direction of the Hindi. A similar diversity would probably be found in some of the Egyptian fields representing the same variety of cotton. With the better varieties such as Mit Afifi and Jannovitch the percentage of dilute hybrids and variants, as of true Hindi and obvious hybrids, is doubtless considerably less though by no means a negligible quantity.

It would probably be well within the truth to estimate that the results obtained by counting would at least be doubled if they were to include the later generations of hybrids and dilute crosses that increase the diversity and diminish the value of the crop. If the average of the percentages shown in the different countings of Hindi plants be accepted as the basis of calculation, a total estimate of about 12 per cent would represent the extent of the Hindi contamination that would become visible under a more careful inspection of the Egyptian fields. Estimated even at 10 per cent, the annual damage of the Hindi cotton must run well above $10,000,000, perhaps even to twice that amount. It is true, of course, that any definite figures must be in the nature of guesswork; they can serve only in a general way to indicate the magnitude of the factor of diversity in the Egyptian cotton crop.

While the cotton of the Hindi and other variant plants is not altogether worthless, there can be no doubt that the crop as a whole would be far more profitable to the farmer if all these plants were destroyed, even though nothing took their places. A general diminution in yield is due to the infertility of many of the hybrids and other aberrant plants; a general depreciation of the value of the crop is due to the residuum of inferior cotton that the sorting does not remove, to the expense of the sorting, and to the relative waste of labor in growing and picking the low-grade cotton. These elements of loss recur with every season and represent a large tax upon the industry. They also represent roughly the advantage that American farmers may hope to gain by paying more effective attention to the factor of selection as a means of maintaining the purity and productive efficiency of varieties.

OTHER CAUSES OF DETERIORATION OF THE EGYPTIAN CROP.

While an increase of the proportion of Hindi cotton would explain a reduction in the yield as well as in the quality of the crop, it is probable that other causes are responsible for a share in the decline. Indeed, some writers on the subject, overlooking the Hindi factor, have used considerable ingenuity in imagining other causes of deterioration and are calling for radical measures of reform to check, if possible, the downward tendencies. Statistics indicate a general decline in production at the rate of about 100 pounds of lint per acre during a period of about 12 years. Such a reduction is a very serious matter from the standpoint of the native cultivator who operates on a very small piece of land at a very high rental. Even when the tenant has to pump his own irrigation water his rent may run at the rate of $40 or $50 per acre. Under favorable conditions a return of $100 may be secured, but the margin is often very narrow, only $5 to $10 for a season's work.

In spite of the decline in yield, the increase of the area of production by new irrigation works may maintain or even increase the total output of the country as a whole, though it is evident both in Lower and Upper Egypt that the extension of cotton into newly reclaimed areas is likely to be a very gradual process attended by considerable difficulties. Other possibilities of extensive cotton production are said to exist in the Egyptian Sudan, where many efforts for agricultural progress, including large projects in irrigation, are now being made.

One of the favorite theories to account for the lessening yields of cotton is that the varieties have run out. This theory may be true in the sense already discussed, that of deterioration due to hybridism and resulting diversity, but it is probably not true in the sense that is commonly supposed, that the varieties have weakened and declined in vigor and fertility. With plants long propagated from cuttings, such as strawberries and potatoes, it is believed that old varieties become weaker and less resistant to disease after a period of a few decades, but with open-fertilized, seed-propagated plants like the cotton, the idea of varieties running out is not considered as having received any adequate demonstration. Some of the native cultivators declare that all the plants used to grow as large on their land as the tall hybrids do now and that they were fertile in proportion to their size, but such a difference might be due to a decline in the fertility of the soil as well as to a deterioration of the variety.

The tradition of perpetual fertility of the Egyptian soil, annually renewed by the sediment deposited by the flood of the Nile, does not apply to the cotton lands, for this crop is raised on an entirely different system having no relation to the agriculture of

ancient Egypt. Ancient Egypt depended on winter and spring crops that could be grown during the intervals between the summer inundations, but cotton requires the whole warm season, spring, summer, and autumn. It has to be irrigated in the spring before the floods come and is harvested during the flood period. Cotton can be grown, therefore, only on land that is protected from the floods and provided with canals for perennial irrigation. The only Nile mud that comes to these lands is a very little in the turbid water of the later irrigations that are given to the cotton after the river rises. There is no deposit of mud from large volumes of water turned into basins and allowed to settle as under the old system of irrigation at flood time. Hence there is every reason to expect a gradual decline in the fertility of the cotton lands, a decline likely to be noticed first in the lighter and poorer soils but also likely to affect the others in time. Whether this decline has already become a serious factor in reducing yield might require a very careful investigation to determine, but it is very likely to be a contributing factor.

The use of fertilizers is already recognized as a serious question in relation to the cotton industry. As in the United States, natural and artificial manures are used with pronounced benefit on the poorer and lighter lands while the heavier soils show little or no response. The domestic supply of fertilizing material is greatly reduced by the natives in their universal use of the dung of domestic animals as fuel. Some writers have seen an evidence of agricultural efficiency in the making of such material up into cakes and hoarding it around the native houses, but the object is to cook the family meals, not to fertilize the land.[a]

A theory receiving much attention at present is that the decline of the cotton crop is due to a rise of the water table or level of the subsoil water in the soil, resulting from infiltration from canals and the use of larger quantities of water for irrigation purposes. While it is evidently true in Egypt, as in the United States, that too much water is bad for cotton, it hardly seems probable that the change of the water table has been sufficiently serious and general to be responsible for any very large part of the decline of the crop. The recent improvements of irrigation facilities are making it easy for the cultivators to injure their crops by using too much water, a tendency that seems to be very general in irrigated regions. Indications of such injury could often be seen in the fields. In some cases continued excess of water had evidently interfered with growth, so that the cotton of the water-logged fields remained very small. In other cases excess of water appeared to be responsible for too vigorous

[a] Foaden, G. P. Notes on Egyptian Agriculture. Bulletin 62, Bureau of Plant Industry, U. S. Dept. of Agriculture, pp. 26–33.

growth and late fruiting, with the probable result of a smaller crop. American cotton planters are familiar with the fact that too much rain often cuts down the crop by inducing additional growth near the beginning of the fruiting period. A whole crop of buds or young bolls may be shed that would have grown to maturity if the weather had continued dry.

Cotton growing on lands along permanent watercourses in the Zagazig district, where the water table must have been kept within a few feet of the surface, did not show any serious impairment except for a few rows along ditches or ponds that supplied water practically on the surface. The small size and pale color of one or two rows along the dikes often indicated serious injury by the close proximity to water, but usually there was a rapid improvement farther back. A recent publication gives the results of many investigations of water level in wells and concludes that the modern system of irrigation has had no serious general effect in raising the level of the subsoil water. On the other hand, it is pointed out that a secondary artificial water table may be formed when superfluous irrigation water collects over an impervious subsoil layer.[a]

Disease also may play a part in the decline of production. As pointed out by Mr. Fletcher, in the vicinity of Gizeh some of the fields of cotton show irregular patches of very inferior plants, with

[a] Ferrar, H. T. On the Creation of an Artificial Water Table in Egypt, Cairo Scientific Journal, vol. 4, p. 153, July, 1910.

The conclusions of this paper are stated as follows:

"It is reasonable to suppose that a small quantity of water has been retained by the alluvium each succeeding year, for it is not likely that a great augmentation of subsoil water would take place in a year or two, and in the absence of substantiated evidence we must assume that by degrees water has been accumulating in the soil since the introduction of perennial irrigation. Observations made in the provinces of Menufia and Gharbia have shown that at the present time (May 1) a layer of saturation may be found which is seldom more than two meters below the soil surface. The upper surface of this artificially saturated layer has been called the *artificial water table.*

"Some misapprehension exists with regard to the water which is found in the Nile alluvium and it will be of interest, therefore, to state tentatively two main conclusions drawn from observations made at more than 150 experimental tube wells which have been under observation during the past year. The observations made at these wells in Lower Egypt all support the view that there are two water tables:

"1. *A natural water table which is independent of the works of man, except locally where extra permeability allows a constant supply of irrigation water to be added.*

"2. *An artificial water table which was created by the act of the introduction of perennial irrigation by Mohammed Aly Pasha.* It is thought that *this artificial water table has gradually become higher, owing mainly to excessive watering of crops,* until at the present day it has a deleterious effect upon the fertility of the soil."

some dead and dying. On examination of the roots Mr. Fletcher found the fibro-vascular bundles stuffed with fungous mycelium as in the wilt disease of cotton in the United States. Samples of roots of cotton plants affected in the same way were also sent by Mr. Fletcher some years ago to Mr. W. A. Orton, of the Bureau of Plant Industry, but no definite identification of the disease could be made.

It has been supposed that the Egyptian cotton is resistant to the wilt disease, but that this resistance is not absolute seemed to be shown very clearly in one of Mr. Fletcher's experiments already noted. In a type of cotton practically resistant to such a disease a large amount of unrecognized damage might be done. Mr. Orton states that in the United States the wilt disease is responsible for much damage outside of the most seriously infested areas where the plants are killed.

PROSPECTS OF EGYPTIAN COTTON IN THE UNITED STATES.

Though it is to be expected that the Hindi contamination and other causes of decline of the cotton crop in Egypt will eventually be recognized and removed, there is no reason to expect any sudden or complete change in the present conditions. The yield and quality may be expected to fluctuate somewhat with the seasons, but such differences are likely to be less serious in Egypt than in almost any other country.

The Hindi cotton might be eliminated eventually if a better system of selection were applied or new and uniform strains could be developed and substituted for the present diverse stocks. More extensive fertilizing might counteract the diminishing fertility of the soil. Drainage works are being extended and improved methods of controlling insect pests are being applied. More hardy varieties may also be developed, analogous to the wilt-resistant varieties of Upland cotton bred by Mr. Orton in the United States.

But all of these measures are likely to require considerable periods of time, quite as long, indeed, as would be needed for the elimination of the Hindi, and this will give our newly established cotton-growing communities of the Southwest a fair opportunity to market their first crops, if they decide to undertake the production of Egyptian cotton on a commercial scale, instead of the short-staple Upland cotton they are now planting. One of the difficulties in establishing such an industry is that it needs to begin on a sufficiently large scale to provide the necessary ginning and baling facilities. Manufacturers are not willing to buy small quantities of cotton from a new region.

No assurance can be given, of course, that the present high prices of Egyptian cotton will be maintained for even a few years. The farmer will have to judge for himself whether the normal relations

of supply and demand are likely to continue and to have their normal influence on the prices. The present status of the Egyptian industry is only one factor of the problem, but the prospects in this quarter seem to favor the proposed establishment of an Egyptian cotton industry in the Southwest.

It need not be supposed that the culture of Egyptian cotton in the United States will involve an injurious competition with the Egyptian industry. The irrigated districts of Arizona and southern California where the experiments with the Egyptian cotton have been carried on are not very extensive, nor thickly populated. Settlement is going on in a very gradual way, as irrigation facilities are provided. Moreover, the opening of an additional source of supply of Egyptian cotton would be likely to improve the commercial prospects of this type of fiber. The danger is already recognized in Egypt that if prices remain too high markets may be lost by the further substitution of inferior kinds of cotton in fabrics for which Egyptian has been used.

Recently published results of an investigation of this question show that an extensive substitution of other types of cotton for the Egyptian has already taken place and that there has been a serious decline in some lines of Egyptian cotton goods as a result of improvements in the weaving machinery and finishing processes that make it possible to use cheaper materials not previously employed for such purposes. The plan of substitution seems to have succeeded beyond all expectations, as the following statements will show:

> It is in these lower grade goods that the substitution of American for Egyptian yarns has shown the most marked development. The substitution has taken place in various ways, but all due to the one cause—the great difference in price between American and Egyptian yarns. The high price of Egyptian cotton has compelled the spinners to devote their attention to producing a finer spun yarn from American staple than was formerly thought possible. Until a few years ago 40's were regarded as practically the limit of American spinning. Now by improved processes and the adoption of finer methods of spinning (e. g., combing, which was formerly confined to Egyptian yarns) 60's, 70's, and 80's of satisfactory quality can be spun from American. Though perhaps not equal in strength to the Egyptian yarns of the same count, these yarns have proved an excellent substitute in many branches of the trade. * * *
>
> The secondary difficulty of overcoming the dealers' prejudices against American cotton was of short duration. Most of the goods in question were well-established stock lines which the dealers had sold for some years at fixed prices, and to raise these prices was impossible. But the rise in price of the Egyptian yarns was too great to be covered by any possible sacrifice of profits on the part of the manufacturers or the dealers, and there was no alternative but to abandon the Egyptian yarns. Had such a suggestion been made a few years ago, it would have been ridiculed; but the shopkeepers, more than half persuaded by the obvious excellence of the goods, were compelled to try them, and their success was immediate and astonishing. Customers showed no

hesitation in choosing between the old goods at enhanced prices and the new cheaper goods, and the success of the latter in use rapidly disposed of any fears of their practicability. The customers either did not know the difference or were quite pleased with the substitute. * * * The result is that the trade in those fabrics, where the substitution of cheaper cotton was impossible, has dwindled to very small proportions. The consumers declined to pay the high prices, preferring goods of cheaper quality at something like the old prices. And the manufacturers have not been slow to meet the requirements of the market. Much of the cotton trade is season's goods, and even the established stock lines may suffer a serious loss of demand in one season through the appearance of new goods in competition. The manufacturers have therefore placed before their customers alongside of the old goods at increased prices entirely new and cheaper goods of different materials and new designs which have proved eminently successful. Thus in the end substitution though impossible directly has won its way indirectly to the same result; the old fabrics made from the expensive Egyptian cotton have been largely replaced by new fabrics of cheaper materials mostly American.[a]

It would be a mistake to suppose that the problem of uniformity can be completely solved by breeding and selection, however carefully and efficiently done. The quality of the fiber depends on favorable conditions of growth that often vary in the same field. Even the same individual plant may produce entirely different grades of fiber as a result of changed conditions during the same season. Any sudden forcing or checking of growth is likely to injure both the yield and the quality of the cotton crop. A large amount of experimenting may still be necessary to determine the best methods of culture and irrigation to secure the largest yields and the best quality of lint.

The cultural problems are not the same as with crop plants where the chief object is to promote vigorous growth and a large bulk of plant tissues. With cotton both the yield and the quality are likely to be cut down if the plants are too large and luxuriant. The tendency to overgrowth is a serious difficulty with the Egyptian cotton on some of the very rich new soils in the Southwestern States. How to hold this undesirable luxuriance in check is one of the chief problems. Earlier crops, larger yields, better fiber, and easier picking can all be obtained if the excessive growth of the plants can be restricted. Nor can the new cotton-growing districts be expected to prosper on the basis of a single crop, however profitable it may appear to be at first. To grow cotton continuously on the same soil in an irrigated region is likely to invite disease. Rotations of crops and other forms of diversified agriculture will be needed to insure permanent prosperity.

[a] See Todd, John A., "The Market for Egyptian Cotton in 1909–1910," L'Egypte Contemporaine, no. 5, January, 1911, pp. 3, 4, and 6.

CONCLUSIONS.

The standards of uniformity are higher with the Egyptian cotton than with American short staples, because the Egyptian cotton is used for superior fabrics and for other industrial purposes where strength is required. The prospects of establishing a successful Egyptian cotton industry in America depend on the possibility of producing a uniform crop and avoiding the need of a subsequent sorting of the fiber.

In the Egyptian industry the requirement of uniformity is met, in part, by a system of careful grading and sorting, made possible by cheap labor not available in the United States. Inspection of the fields in Egypt during the early part of the growing season shows a large and very general contamination with the inferior type of cotton known as Hindi that produces only a short, sparse, white lint, quite unlike that of the true Egyptian cotton.

The claim that the Hindi cotton is all removed from the field at the time of thinning the plants is not warranted by the facts, for the Hindi type and obvious hybrid forms are to be found in nearly all the fields, often in considerable proportions, sometimes more than 10 per cent of the total number of plants. Removal of the Hindi plants is practiced only at the period of thinning and very seldom results in any complete elimination of the Hindi cotton from the fields.

The injury caused by the Hindi contaminations is not limited to the proportion of Hindi plants and obvious hybrids that were counted in the fields. Many plants not readily distinguished as Hindi hybrids at earlier stages of growth, give later indications of hybrid nature in white flowers, pale-green bolls, or sparse, inferior lint, or in relative or complete sterility. The Egyptian system of roguing the plants only at the time of thinning would not effect a complete elimination of the Hindi cotton, even if it were generally applied.

An increase of the Hindi contamination is popularly supposed to have taken place in Egypt, in spite of the selection that has been directed against it. Such an increase would be able to cause a serious decline in the yield as well as in the quality of the Egyptian crop, quite independent of other possible causes of deterioration that are supposed to explain the lessened production of the Egyptian fields, such as diminished fertility of the soil, rise of the water level in the soil, plant diseases, and insect pests.

The supposed increase in the proportion of Hindi cotton may prove to be due to the naked seeds that permit a more rapid absorption of water and a more prompt germination than fuzzy seeds. Prompt germination would allow the Hindi seedling plants to make more rapid growth in the earlier stages and thus gain an advantage over Egyptian seedlings in the same hill. It is also possible that the

Hindi characters are prepotent over the Egyptian, like the Upland characters in the later generations of Egyptian-Upland hybrids.

Breeding experiments have shown that it is possible to secure a much higher degree of uniformity in Arizona than now exists in most of the cotton fields in Egypt. Attention to the external characters enables the Hindi cotton and other undesirable variations to be removed from the fields before the flowers open and hence before cross-fertilization becomes possible. If reasonable care be used in maintaining the uniformity of these types, it does not appear that the American-grown Egyptian cotton is likely to suffer any commercial disadvantage on the ground of lack of uniformity in comparison with the Egyptian crop, even though we do not go to the expense of establishing large ginning establishments where the cotton is laboriously sorted by hand.

The greater popularity of the brown-linted varieties of Egyptian cotton may be explained by the advantage that the color gives in sorting out the inferior white Hindi fiber. The exclusion of the Hindi cotton by a more efficient system of selection will enable white varieties to be grown in Arizona and thus produce longer and stronger fiber than brown varieties are likely to afford. A study of many variations and hybrids of the Egyptian cotton shows a distinct tendency for the brown color to be associated with short fibers.

It is possible that the reversions to the Hindi characters may continue to appear in small numbers, even in carefully selected stocks, as in analogous naked-seeded variations occasionally found in uniform carefully selected varieties of Upland cotton. Nevertheless, experiments indicate that such reversions to the Hindi characters are not likely to interfere with the development and preservation of uniform strains of Egyptian cotton in the United States if the proper methods of selection are applied.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—Cotton field at Benha, Egypt, showing size and habits of growth of Egyptian cotton plants at the middle of June. Fig. 2.—Closer view of an Egyptian cotton plant with a Hindi plant on either side.

PLATE II. Fig. 1.—View from the outside of the cotton field shown in Plate I. Fig. 2.—General view of a larger field, showing differences in the conditions of the plants at the middle of July.

PLATE III. Bracts and calyxes of Hindi cotton: *A*, From a plant grown at Gizeh, Egypt, by Mr. F. Fletcher from seed obtained in Mesopotamia; *B*, *C*, from two flowers of Hindi cotton from Fayum, Egypt. (Natural size.)

PLATE IV. Bracts and calyxes of cotton from Calioub, Egypt: *A*, Egyptian; *B*, Hindi hybrid. Note the longer laciniæ on the Hindi hybrid bracts; also, that the calyx teeth are intermediate between the Egyptian (Pl. IV, *A*) and the Hindi (Pl. III, *A*, *B*, *C*). The teeth on one side of the Hindi hybrid calyx are rolled back in the photograph. (Natural size.)

PLATE V. Bracts and calyxes of cotton grown at Gizeh, Egypt: *A*, *B*, Of two flowers of Hindi-like Upland cotton from Cochin China, grown by Mr. F. Fletcher; *C*, of a relative of the Egyptian cotton from the Niam-Niam country of central Africa, grown by Mr. W. Lawrence Balls.

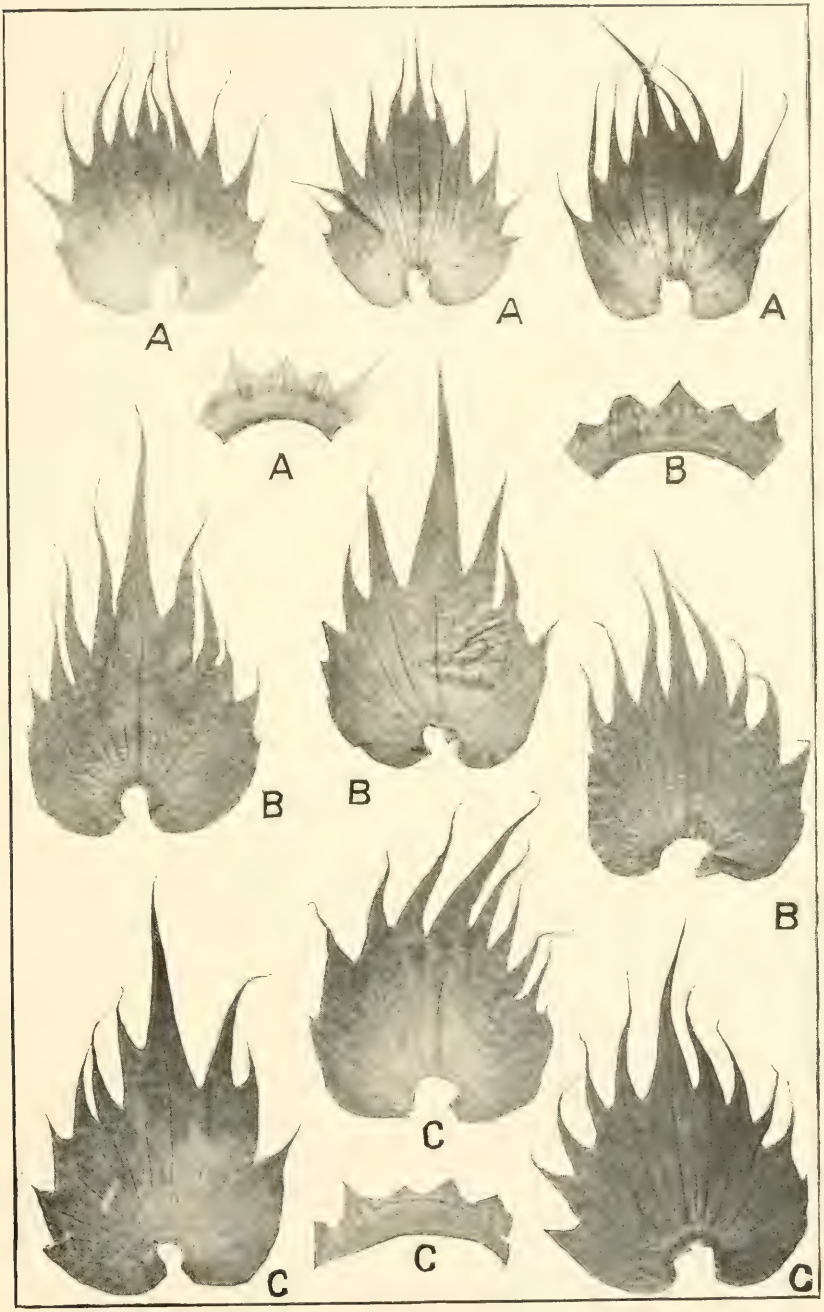
PLATE VI. Bolls of Egyptian and of Hindi cotton grown at Somerton, Ariz., in the season of 1909, showing differences in the shape and the markings of the surfaces: *A*, Egyptian; *B*, Hindi. The tooth calyx of the Hindi cotton can be contrasted with the truncate saucer-like calyx of the Egyptian. (Natural size.)

FIG. 1.—A FIELD OF EGYPTIAN COTTON INTERMIXED WITH HINDI.

FIG. 2.—AN EGYPTIAN COTTON PLANT BETWEEN TWO HINDI PLANTS.

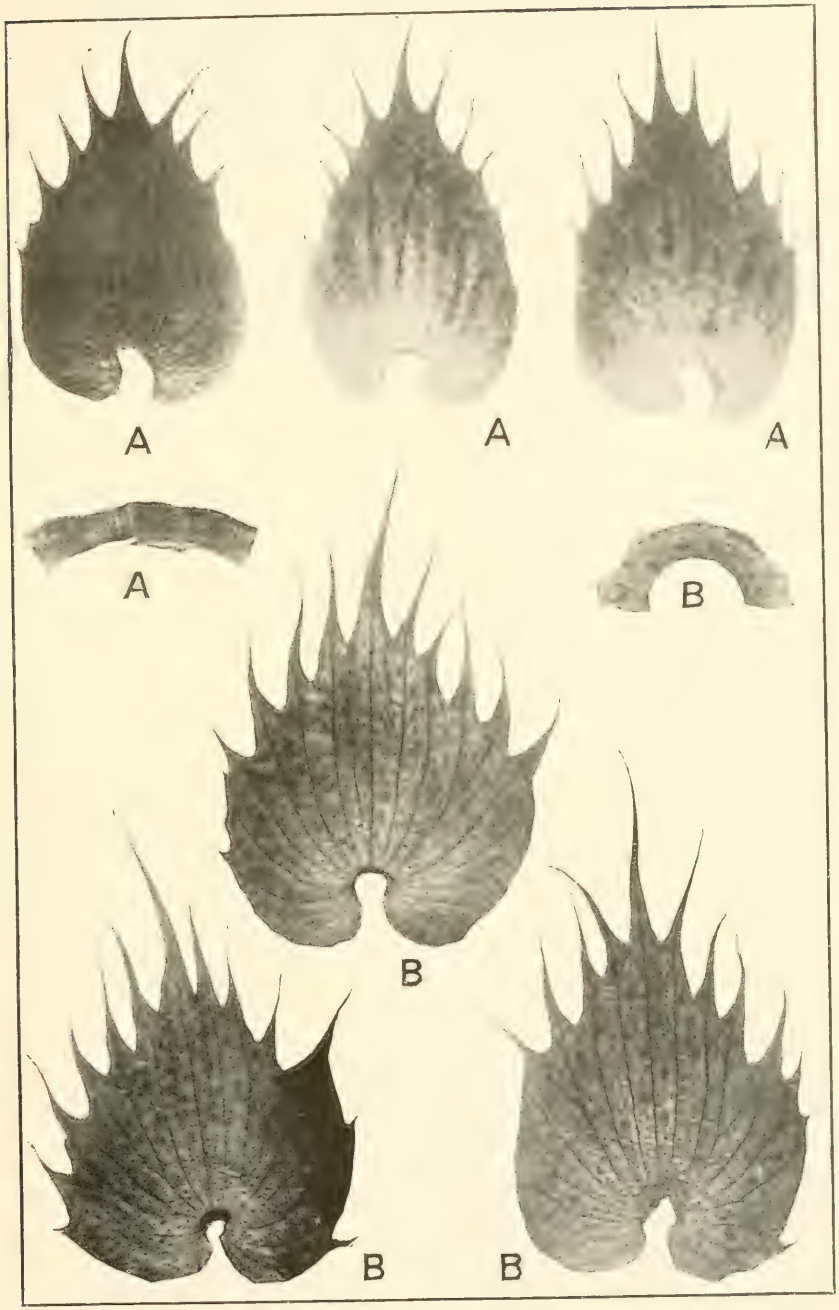
FIG. 1.—SMALL COTTON FIELD AT BENHA, EGYPT.

FIG. 2.—LARGE COTTON FIELD AT BENHA, EGYPT, WITH NATIVES IRRIGATING.



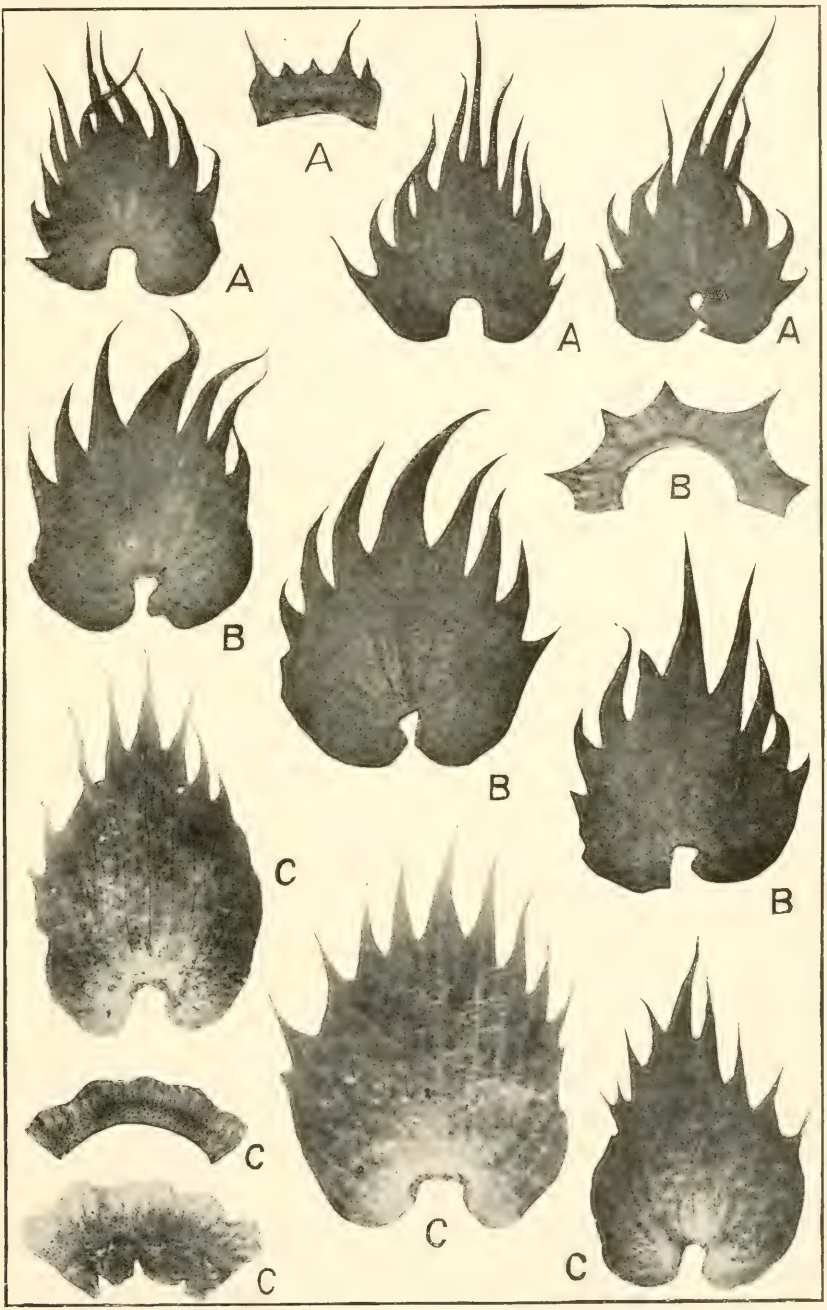
BRACTS AND CALYXES OF HINDI COTTON: A, FROM MESOPOTAMIA; B AND C, FROM FAYUM, EGYPT.

(Natural size.)



BRACTS AND CALYXES OF COTTON: A, EGYPTIAN; B, HINDI HYBRID.

(Natural size.)



BRACTS AND CALYXES OF COTTON: A AND B, HINDI-LIKE UPLAND FROM COCHIN CHINA; C, A RELATIVE OF THE EGYPTIAN FROM CENTRAL AFRICA.

(Natural size.)

BOLLS OF COTTON: A, EGYPTIAN; B, HINDI.

(Natural size.)

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